National Library of Canada
Bibliothèque nationale du Canada

Canadian Theses Service
Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

NL-339 (r. 88/04) c

Canada

National Library of Canada
Bibliothèque nationale du Canada

Canadian Theses Service
Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-55347-2

Canada

UNIVERSITY OF ALBERTA

REFLECTION IN LOGO CONTEXTS: A CASE STUDY

by

Frances Galbraith

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND

RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF EDUCATION

DEPARTMENT OF ELEMENTARY EDUCATION

EDMONTON, ALBERTA

FALL 1989

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: Frances Galbraith

TITLE OF THESIS: Reflection in Logo Contexts: A Case Study

DEGREE: Master of Education

YEAR THIS DEGREE GRANTED: 1989

PERMISSION IS HEREBY GRANTED TO THE UNIVERSITY OF ALBERTA LIBRARY TO REPRODUCE SINGLE COPIES OF THIS THESIS AND TO LEND OR SELL SUCH COPIES FOR PRIVATE, SCHOLARLY OR SCIENTIFIC RESEARCH PURPOSES ONLY.

THE AUTHOR RESERVES OTHER PUBLICATION RIGHTS, AND NEITHER THE THESIS NOR EXTENSIVE EXTRACTS FROM IT MAY BE PRINTED OR OTHERWISE REPRODUCED WITHOUT THE AUTHOR'S WRITTEN PERMISSION.

Frances Galbraith

10510 - 135 Street

Edmonton, Alberta

T5N 2C7

Date: Oct. 12, 1989

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

THE UNDERSIGNED CERTIFY THAT THEY HAVE READ, AND RECOMMEND TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH FOR ACCEPTANCE, A THESIS ENTITLED **REFLECTION IN LOGO CONTEXTS: A CASE STUDY** SUBMITTED BY FRANCES GALBRAITH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION.

D. Sawada (Supervisor)

J. Edwards

J. Parsons

Date: Oct. 6, 1989

DEDICATION

This thesis is dedicated to my parents, Ed and Margaret Galbraith who have influenced this project through the years. My father's quiet encouragement of exploring the unknown combined with a determination inherited from my mother provided the impetus for this project.

ABSTRACT

Reflection, as a component of the Logo programming language, is part of an interactive network consisting of the resultant processes of interaction between child, Logo, and context. This study focussed on reflection within this network.

Case studies of four pairs of grade 5 & 6 students were developed from observational notes, videotapes of their onscreen computer work, interviews, examination of computer books, and audiotapes of conferences held with two of the groups.

An examination of the data and the case studies with respect to reflection within the system revealed a similarity in reflective methods employed by the groups, that an emphasis on reflection could influence process, and a model for the development of a process network.

The process network was generated through verbal discourse. Cooperation was essential between participants to create communication from their talk. In addition, collaboration created a cohesive network out of communication. The spiralling development of ideas within the network created a community of thought which generated an evolving network.

The model of a generative process network was evident in the process networks developed between students as well as those developed between the students and the researcher. The participating groups attained different positions of development depending upon the level of cooperation and collaboration created within their network.

It was evident that reflection does occur within a Logo network, attaining varying levels of development throughout a generative network.

ACKNOWLEDGEMENTS

I express appreciation to the many people who assisted in the completion of this thesis.

My sincere thanks are extended to:

Dr. D. Sawada for his supportive guidance and understanding, as ideas developed.

Dr. J. Edwards and Dr. J. Parsons as committee members.

The staff and students at the participating school who made me welcome and assisted in many ways.

My family and friends for their continual support.

TABLE OF CONTENTS

CHAPTER 1

A. INTRODUCTION.....1

B. PURPOSE OF THE STUDY.....6

C. QUESTIONS.....6

D. DESIGN OF THE STUDY.....6

E. DELIMITATIONS.....8

F. ORIENTING DEFINITIONS.....8

G. SIGNIFICANCE OF THE STUDY.....9

CHAPTER 2

LITERATURE.....10

Logo.....10

Problem Solving.....16

Metacognitive Development.....18

CHAPTER 3

METHODOLOGY.....23

A Conceptual Model of Logo Reflection.....24

A Case Study Method.....26

THE DESIGN OF THE STUDY.....27

ANALYSIS OF THE DATA.....32

Methods of Reflection.....32

Researcher's Comments.....35

Frustration.....36

THE ROLE OF THE RESEARCHER.....37

CHAPTER 4

CASE STUDIES.....38

CASE ONE; JEAN AND KAREN.....38

Reflection.....42
Context.....44
Microworld.....44
Process Network - student/student.....50
Process Network - student/student/researcher.....55
CASE TWO: ROSS AND SIMON.....56
Reflection.....61
Context.....62
Microworld.....62
Process Network - student/student.....64
Process Network - student/student/researcher.....67
CASE THREE: ANNA AND SUSAN.....68
Reflection.....73
Context.....76
Microworld.....76
Process Network - student/student.....78
Process Network - student/student/researcher.....82
CASE FOUR: MIKE AND ALAN.....93
Reflection.....97
Context.....98
Microworld.....98
Process Network - student/student.....100
Process Network - student/student/researcher.....102
CHAPTER 5
FINDINGS OF THE STUDY.....106
METHODS OF REFLECTION.....106
WHICH METHODS OF REFLECTION WERE USED?.....109

Guess - Check - Adjust....114
Talk....115
Other Methods....119
CONTEXT....120
Describing microworlds....120
Pairing....120
Control Within Logo....124
Amount of reflection....126
Methods of reflection....127
Approach....127
Summary....128
PROCESS NETWORK - STUDENT/STUDENT....129
Microworlds within a Process Network....129
Communication....130
Collaboration....133
Pairing....138
Reflection....140
Summary....144
SUMMARY....145
PROCESS NETWORK - STUDENT/STUDENT/RESEARCHER....146
Anna and Susan....146
Mike and Alan....156
A COMPARISON OF THE GROUPS....159
A COMPARISON OF THE CONFERENCED AND NON CONFERENCED GROUPS....162
SUMMARY....165
CHAPTER 6
CONCLUSIONS....166

SUMMARY.....166
THE RESEARCH QUESTIONS REVISITED.....167
Microworld.....169
Reflection itself.....170
Control within Logo.....170
Pairing.....170
Talk.....171
Systematic Approach.....171
PROCESS NETWORKS.....172
Collaborative network.....173
Noncollaborative network.....174
IMPLICATIONS.....174
SUGGESTIONS FOR FURTHER RESEARCH.....177
REFERENCES.....181
APPENDIX A.....185
ASSIGNMENT #1 RECTANGLE TESSELLATION.....186
ASSIGNMENT #2 SEMITESSELLATION.....197
ASSIGNMENT #3 LETTERS USING VARIABLES.....205
ASSIGNMENT #4 MONOGRAM USING VARIABLES.....212
ASSIGNMENT #5 DESIGN.....220
ASSIGNMENT #6 DIVIDING RECTANGLES.....226
ASSIGNMENT #7 CASTLE.....234
APPENDIX B.....245
APPENDIX C.....254
APPENDIX D.....262
APPENDIX E.....266
APPENDIX F.....267

LIST OF FIGURES

FIGURE 1. Levels of Reflection.....25

FIGURE 2. Sketch.....82

FIGURE 3. Reflective Methods - Jean and Karen..109

FIGURE 4. Reflective Methods - Ross and Simon..110

FIGURE 5. Reflective Methods - Anna and Susan..110

FIGURE 6. Reflective Methods - Mike and Alan...111

FIGURE 7. Most Common Reflective Methods - Jean and Karen.....112

FIGURE 8. Most Common Reflective Methods - Ross and Simon.....112

FIGURE 9. Most Common Reflective Methods - Anna and Susan.....113

FIGURE 10. Most Common Reflective Methods - Mike and Alan.....113

FIGURE 11. A Model of a Generative Process Network.167

CHAPTER ONE

INTRODUCTION

In the industrialized nations computers have penetrated almost every area of endeavour. Our lives are controlled by computer transactions: we buy and sell through computer contracts; we receive money and pay bills by pushing buttons; our lives are filed in data bases. In the midst of this technological transformation, educators are struggling to find a place for computers in education. Of what use are computers to students and teachers? Should they be used only for job training or should a computer be on every student's desk? Should computers deliver curriculum or be employed by teachers as a teaching tool? Should schools be teaching programming or using drill and practice programs?

As this struggle continues, teachers have developed computer components to their programs which have evolved from the needs of their classrooms. In a similiar fashion, over the years I have experimented with many programs, orientations and approaches to using computers with my students. During this period I was introduced to a computer language which could be used with elementary students and was proclaimed to produce miracles with

little or no teacher effort. This "panacea" was Logo as developed by Seymour Papert and his associates at the Massachusetts Institute of Technology. The Logo language allows students to program the computer to move a "turtle" to make a graphic display. Although Logo is a complete programming language, the graphic function is the one used most frequently with elementary students. I used various versions of this language with students from grade 1 - 6 and was impressed by the amount of time students would dedicate to a project, by the imaginative products they would create and by the variety of graphic images that would result from a project. This appeared to be the kind of open ended medium in which thinking and problem solving skills develop. Since I had begun graduate studies in computer applications, Logo seemed a natural topic to explore.

Papert's (1980) assertion that children using Logo worked with and developed powerful ideas confirmed my intuitive belief that Logo produced a medium in which problem solving skills could develop. A specific topic evolved from my search for a classroom in which to conduct the research. While looking for a classroom in which to work, I was dismayed to discover that many of the teachers who had begun using Logo enthusiastically a few short years ago had abandoned it. Why had they deserted such a

shining light? Could it be that they had become disillusioned by the lack of an instant cure as promised? Could it be that having not seen striking demonstrative gains in student achievement, they had rejected the whole idea? This concern with achievement and skill transfer, which may have affected teachers, is predominant in the studies conducted at the Bank Street College of Education [Kurland, Clement, Mawby & Pea (1987); Hawkins (1987); Pea, Kurland & Hawkins (1987b)]. These studies and others [Clements & Gullo (1984); Clements (1986); and Clements (1987)] found little or no evidence of the transfer of problem solving skills to other situations or an increase in cognitive functioning from the Logo experience.

Could it be that a computer language producing such enthusiasm, determination, and creativity in my students, was not fullfilling its promise of developing powerful ideas? Should I too abandon Logo or examine new avenues? Another path had been taken by Emihovich & Miller (1988a & b) and Au, Horton & Ryba (1987) who suggested that positive effects with Logo can be the result of process oriented teacher intervention. Some researchers had looked at the effect of Logo on external factors, while others had looked at what teachers could do, but what about the students? Thus I found my important question: what

exactly do students do when confronted with the problem solving world of Logo?

During the past decade, research in writing has gone from an examination of specific writing skills and their application in instruction to the exploration of the child's writing process. This avenue of research has resulted in a great deal of knowledge about the process of writing and is influencing instruction.

Instead of testing for transfer of skills to other areas or introducing structured curriculum, perhaps Logo research could take a route similiar to writing and take a close look at the child's experience. Calkins (1986) explains that we have had major studies on how children develop as writers. Logo research could benefit from this experience and begin to look at how children develop as Logo users.

Educators tend to follow ideas that promise rose gardens but cut down the whole rose bush when they encounter a thorn rather than carefully tending to the plants. I wanted to step back and watch the flowers grow. I intended to examine a space as close to the Logo experience as possible by looking at the reflection processes used by students in a Logo environment.

Several authors, among them Papert (1980) and Clements & Gullo (1984), suggest that children reflect upon their

actions and make decisions for future action when they are placed in a problem solving situation. These authors also contend that programming in Logo provides a suitable problem solving situation. Because this reflection occurs while working with Logo it is said to be inherent in Logo. Much has been said about the reflection inherent in Logo but researchers have only attempted to measure change in the product of this reflection without examining it within the interactive context of Logo. Reflection, as a component of Logo is part of an interactive network consisting of the resultant processes of interaction between child, Logo, and context. It is reflection within this network, as a process in situ, that was studied.

PURPOSE OF THE STUDY

The purpose of this study was to examine the reflective process in an interactive Logo network.

QUESTIONS

1. What is the nature of reflection in an interactive Logo network?

a) How is reflection imbedded in a Logo process network?

b) What methods do students use to solve their Logo problems?

c) How does the researcher's emphasis on reflection influence the student's work?

DESIGN OF THE STUDY

A Grade 5 & 6 classroom was selected on the basis of the teacher's willingness to participate, the teacher's previous extensive knowledge of Logo and the students' previous experience with Logo. It was felt that previous knowledge was necessary.

Eight students, 4 girls and 4 boys, equally distributed between grade 5 and 6 were selected from among the students who had parental permisssion to participate. The students worked in pairs at the computer. The groups had their Logo work videotaped, without camera, over an eight week period. Field notes were also kept during this time. This information was examined for evidence of reflection and any resultant changes.

Two of the four groups were involved in an extended reflection period after videotape sessions. The students were stimulated to recall their actions and thinking by watching the videotape replay of their work. They were also encouraged to examine their own thinking, their problems and their plans during this reflection time which was audiotaped.

At the end of the research period, each participant was interviewed by the researcher (See Appendix F).

Transcriptions of the videotapes and audiotapes as well as the field notes were analysed for evidence of the types of reflection occurring, the methods of reflection students used and the effect the imposed reflection time had on future work.

These analyses provided the basis for the development of the case studies presented in Chapter Four. Comparisons of the groups through the case studies were conducted.

DELIMITATIONS

The study was restricted to eight students in one Grade 5 & 6 classroom. The students, teacher and researcher had previous experience with Logo.

The data analysed consisted of transcriptions of the videotapes, transcriptions of the conference audiotapes, observational field notes, the student's computer books, and the transcriptions of the individual interviews.

ORIENTING DEFINITIONS

Reflection is the act of giving careful consideration to a situation. It is thinking about or pondering information to bring about a new state of awareness in the individual. It is an internal process exemplified by children who respond "I did it in my head" to the question "how did you figure that out?". It is an illusive but regularly occurring act in humans. Actions can be associated with reflection although the act of reflection remains internal. In writing a journal to reflect upon performance, teachers are externalizing an

internal process. Writing directions or sketching a diagram put forth a vision of one's thoughts while reflection upon this information remains in one's head for processing.

A **Logo microworld** is a world produced through the interaction of a person with Logo.

A **Logo process network** is a network arising out of the interaction between Logo microworlds.

SIGNIFICANCE OF THE STUDY

This detailed look at reflection in a Logo process network will enable educators to assess its importance and/or relevance to the child working with Logo.

Studying the Logo process network lived by students will give educators a clearer picture of Logo related activities in the child's world.

The use of a case study method will add to the knowledge concerning methodology in Logo studies.

The information derived from this study may be useful to educators who are involved in the implementation of curriculum, especially in the areas of mathematics or general thinking skills or cooperative learning.

CHAPTER TWO

LITERATURE

In this section the literature which may have a bearing on the study will be outlined. Research on Logo in education will be reviewed. Literature in the areas of mathematical problem solving and metacognition will be examined.

Logo

Krasnor (1984) states that "The LOGO experience was designed explicitly to facilitate the learning of powerful ideas, skills and heuristics which transcend the immediate task environment and can be applied in other problem-solving situations" (p. 133). Most of the research involving Logo has been concerned with the transferability of these problem solving skills or cognitive skills to noncomputer or nonLogo situations.

The earliest studies on Logo learning, such as The Brookline project (Papert, Watt, diSessa, & Weir, 1979), indicated a positive effect on the work of children. Although the Edinburgh Logo project (e.g. Howe, O'Shea, & Plane, 1979) indicated mixed evidence of Logo's effect on the development of mathematical skills, researchers were

extremely optimistic about the improvement of general learning skills through the use of Logo. Papert (1980), in describing Logo as not requiring direct teaching, gave the impression that Logo would produce miracles if children were simply put in contact with a computer and Logo. Although Papert (1984) insisted that he had been misinterpreted as saying " Give the child a computer and the child will learn all alone" (p. 426), the studies undertaken at the beginning of the 1980's such as those conducted at the Bank Street College of Education began with the "learning without curriculum" interpretation of Papert (Kurland, Clement, Mawby, & Pea 1987; Pea, Kurland & Hawkins 1987c; Hawkins 1987 or Clements & Gullo 1984).

Papert (1980) also argued that Logo could create situations in which children would work with ideas previously thought too abstract for their developmental level. In this way, Logo could assist in accelerating cognitive development. All of the above studies examined the effects of Logo programming on children's cognition in a "discovery learning" atmosphere. The results of these inquiries were very mixed.

Clements & Gullo (1984) compared the effects of CAI instruction and Logo programming on the cognitive style (reflectivity, divergent thinking), metacognitive ability,

cognitive development, and the ability to describe directions on a group of 18 —six year olds. The Logo group scored higher on the cognitive style, metacognitive abrlity and ability to describe directions components while no differences were found on measures of cognitive development. However, these findings were in part contradicted by the results of a further study by Clements (1986). The 1986 study was larger in scope and found no differences between the Logo and CAI groups on the measure of reflectivity. A further study, Clements (1987), indicated that Logo programming affects certain areas of cognitive functioning and achievement but the connection is not simple.

Kurland, Clement, Mawby, & Pea (1987); Hawkins (1987); and Pea, Kurland, & Hawkins (1987c) were investigating the effect of Logo programming on cognitive skills and whether problem solving skills were transferred beyond programming situations. No significant differences were found between groups who were programming and those who were not programming in any of the studies.

Hawkins (1987) did not find anything to suggest that cognitive skills were being developed in a Logo environment over a one year period. The one change, obvious in the classrooms being studied, was the attitude of the teachers. The teachers began the project using an

open, discovery learning approach but because they were disappointed with the slow development in complexity of the students' projects, they resorted to a more structured skill teaching approach. This change in approach did not appear to have any effect on the program development of the students. Many of the students tended to ignore the teacher's plan or program planning aids and work haphazardly at the keyboard.

Pea, Kurland, & Hawkins (1987c) report that Logo experiences did not have a measurable effect on the planning strategies used by students in other problem solving situations and "programming constructs for the students had local functioning meaning that they did not tend to generalize, even to other closely related programming problems" (p. 187).

Horner & Maddux (1985) were also investigating the effects of Logo experiences on problem solving ability but the results "have not supported that instruction in Logo will positively affect problem-solving ability, produce more positive attitudes toward mathematics, produce more locus of control, or increase the ability to recognize the size of geometric angles" (p.53).

With the publication of such mixed results, it is not surprising that Emihovich & Miller (1988 a & b) and Au,

Horton, & Ryba (1987) expressed concern for the future of Logo in schools. This concern resulted in a new direction of inquiry into Logo. Rather than emphasizing the connection between cognition and Logo, these researchers have been exploring teacher intervention as a factor in producing effects. Their emphasis is on teaching strategies or process, rather than exclusively on questions of transfer of skills or product. Emphasis on process resulted in the use of specific teacher interventions to develop metacognitive skills.

Teachers in Emihovich & Miller's (1988 a) study used specific metacognitive teaching strategies as interventions to stimulate children's learning. The intervention appeared to be effective but as the research is in a preliminary stage the authors do not wish to make recommendations to teachers: "using mediated teaching strategies may be one way to instruct, but whether this has value in promoting the transfer of thinking skills to other tasks remains to be determined (p. 69). In Emihovich & Miller (1988 b), discourse analysis was conducted on the data which indicated that over time "the children are gradually acquiring the ability to shift from other to self-regulation of their behavior" (p. 195).

Au, Horton, & Ryba (1987) believe "that many researchers have failed to take account of: 1) the type of teacher

intervention provided, 2) the sort of learning task provided, and 3) the social context of learning with Logo" (p.12). In their project the teachers used a process-oriented approach or a content-oriented approach to teaching Logo and the results indicate that the students who learned Logo using a process-oriented approach achieved significantly higher gains on a test to measure transfer of problem solving skills than those in the content-oriented group. The students in the process-oriented group were also observed "to interact much more with their peers about their learning and these students were able to solve their programming problems in a much more systematic and methodical way" (p.13). Teacher intervention in this process-oriented approach consists of the use of a series of worksheets, questioning techniques which would encourage students to think about their own thinking, and the development of a socially reflective and interactive environment by encouraging discussion and reflection upon solutions.

Another way in which Logo is thought to benefit learning is through "debugging" or "learning from one's mistakes". Papert (1980) indicates that through the process of correcting and revising programs children must reflect on their own thinking and therefore develop their cognitive processes. Nesher (1987) would agree that student's

misconceptions could provide a learning situation if teachers and students came to use the misconception as an opportunity to correct an error in previous knowledge. Nesher feels that although some people tolerate errors through a sense that "one learns from mistakes", they fail to take advantage of misconceptions as a "feedback mechanism for real learning on the basis of actual performance" (p.34). Stigler (1988) in discussing a comparison of Japanese and American mathematics classrooms indicates the tendency of Japanese mathematics teachers to use a child's incorrect solution as a springboard for discussion. "One can conduct a lot more discussion about errors than about correct errors" (p.29). Handled in the spirit of learning one can learn from one's mistakes.

Problem Solving

Logo and problem solving have been linked since Logo's conception. Clements (1987a) indicated that Logo was developed as a conceptual framework for teaching problem solving skills while Campbell (1988) stated "Logo serves as a setting in which teachers can model and encourage problem solving strategies" (p. 23). Since problem solving skills are thought to be developed by Logo use, factors which are thought to affect problem solving in mathematics may be influential in problem solving within Logo.

Cobb, Merkel, Wheatley, Wood, & Yackel (1988) indicate the importance of having a problem solving atmosphere in the classroom in order to develop positive problem solving attitudes in students such as persistance, viewing problems as personal challenges, and accepting that solutions should be explained and justified. These authors believe that this kind of atmosphere is critical for the development of problem solving skills.

Research reported by Frank (1988) indicates that student's beliefs about mathematics influences their attitude toward problem solving. According to Frank students believe that "mathematics problems should be quickly solvable in just a few steps" (p.33). What does this mean for educators? Efforts must be made to change these views. Frank suggests remedies which are to develop students' belief in themselves as problem solvers and mathematics as a problem solving subject. She suggests that teachers begin problem solving early, focus on solutions not answers, have students work together, and de-emphasize computation.

Another aspect of problem solving which might be influential in Logo programming is the idea of problem solving styles. Flexer (1987) in her case study of two grade one students discovered two distinct problem solving styles employed by the children. Flexer proposes two problem solving styles defined as:

an extrinsic style in which procedures for finding and evaluating solutions exist outside the child, and an intrinsic style in which the child develops and evaluates solutions. The extrinsic problem solver focuses on getting the correct answer; the intrinsic problem solver also has a correct answer as a goal but focuses on the analysis of the problem and the method of solution. (p.120)

Metacognitive Development

Papert (1980) is often credited with the development of interest in the metacognitive effects of Logo programming as a result of his suggestion that in programming children must reflect on how they would do the task and consequently on their own thinking.

"Metacognition refers to the knowledge and control one has of one's cognitive functioning, that is, what one knows about one's cognitive performance and how one regulates one's cognitive actions during performance" (Garofalo, 1987, p.22). Garofalo (1987) goes on to say that "since metacognition has to do with awareness, its development requires one to observe what one does and to reflect on what one observes. Thus, students must become watchers,

analysers, assessors, and evaluators of their own mathematical knowledge and behaviours" (p.22).

Clements & Gullo (1984) and Clements (1986) found that Logo programming was positively connected with some areas of metacognition, especially comprehension monitoring which indicates that one realizes when one doesn't understand.

Of major concern to Emihovich & Miller (1988a) was whether the use of Logo programming affected children's self-monitoring and comprehension processes. They found that the Logo programmers improved in their monitoring performance. As a result of their research, Emihovich & Miller have a model for use in further research on metacognition. The psychological basis of this model comes from Vygotsky's idea that "children's 'higher order mental capabilities' progress from external to internal processes" (Emihovich & Miller, 1988, p.63). They continue by stating that:

> when children 'speak' to the 'turtle' using the appropriate commands, they are externalizing their thought processes as they attempt a solution to the problem (e.g. make a square). The externalization of mental processes through the child's verbal descriptions of ongoing actions and intentions fosters the internalization. The transformation process from externalization to internalization occurs as children

engage in meaningful mediated verbal interactions with adults during Logo. (p.64)

The authors suggest that the internalization of thought processes may occur through a verbal reflection of ideas and that this transformation may be mediated by an adult.

Vygotsky (1978) indicates that the process of internalization of an idea consists of a series of transformations which might be facilitated by an experienced learner sharing knowledge with a less advanced learner. Azmitia (1988) studied collaborative problem solving in preschool children and concluded that "collaboration can lead to greater learning than independent work" and for novices "learning was maximized when children work with an expert partner" (p.94). These authors suggest that collaboration especially with a more expert learner may be benefical to learning.

Surveying the literature highlighted the apprehension I felt that something was amiss in Logo research. Papert's total freedom approach appears to be insufficient in developing the potential use of Logo for the majority of students. In contrast to Papert's optimism for the generation of powerful ideas through Logo programming, researchers have negated the idea that lasting problem solving skills could be developed through nonmediated Logo

use. The juxtaposition of these views has produced a war of words over the future of Logo in schools. Maddux (1989) emphasizes that "controversy itself is not detrimental to a discipline. In fact, disagreement and debate are generally considered the lifeblood of inquiry" but he shares my concern that the effect of the dispute might be "the baby being thrown out with the bath water. Too often in education, promising methods are prematurely abandoned when the first crude research fails to provide evidence supporting the inflated claims of radical advocates" (pg. 19).

Fortunately, some researchers have turned their attention from measuring the effects of Logo on production to teacher mediation and discourse analysis. But all of these efforts have produced bits of information suspended in space. Where is the base? Reflection has become synonomous with Logo and problem solving: a necessary ingredient in building a Logo microworld. But, in what ways do students actually reflect in facilitating Logo development? Are students aware of reflecting upon their work and the methods they are using as Garofalo (1987) indicates is imperative for metacognitive development? Does context affect the student's reflection?

In order to build on the possible benefits of Logo use, one might begin with an exploration of the child's

reflective process. The present study was an attempt to deal with a neglected link in the Logo sphere - the Logo participants' reflective world.

CHAPTER THREE

METHODOLOGY

The choice of methodology was influenced by my desire to concentrate on children and their experiences, the number of levels of context produced by the Logo interactive network and my desire to study this network in a holistic fashion.

While designing this study, I realized that an important area for consideration was the method of study for questions dealing with Logo. Papert (1987) insists that new methods are needed because experimentation is not appropriate, while Pea (1987a) contends that Logo must stand up to experimental tests. Many of the authors who have been a part of this debate recommend that both qualitative and quantitative methods be employed. Some (Emihovich & Miller 1988, Walker 1987, and Becker 1987) suggest the use of a mixture of methods in the same study while others (Salomon & Gardner 1986) advocate qualitative methods be carried out first in order to identify factors which influence the process and then conduct experimentation involving these factors.

While these researchers argued over methods it seemed to me that Emihovich & Miller (1988) state the problem

clearly in saying that Logo "creates a context for learning. And in that context the processes by which children learn and develop using computers is as important as the products, or outcomes, of learning (p.57). But if process is important, how do we study it? Process is not an individual entity which can be separated out for inspection. Since processes are interwoven into a network interacting with contextual factors, this process network needs to be studied in a holistic fashion. A desire to focus on the childrens' actions and reflections, occurring within an interactive network, led to the choice of a case study model which would allow for this concentration while providing the scope necessary for the exploration of the contexual networks.

A Conceptual Model of Logo Reflection

As well as my desire to concentrate on children, I needed to examine the structure of the system I was exploring. Two levels of reflection were present in this study. Individual interaction with Logo generates Level 1 reflection. In other words a child, reflecting interactively with Logo, would produce a microworld. In this study two situations producing Level 2 reflection were studied. One situation was produced through video stimulation in a conference setting with the group members and the researcher. This intentionally produced reflection

was intended to accent the Level 1 reflection a child encounters and explore the possibilities for reflection in an educational context. Level 2 reflection also occurred during the interaction between students. The addition of contextual factors (researcher, equipment, and other students) to interact with the child's microworld would produce a network which I call a process network. It was hoped that the stimulation of Level 2 reflection would assist in developing an understanding of the child's Logo experience.

The existence of three levels of context within the two levels of reflection also affected the choice of methodology.

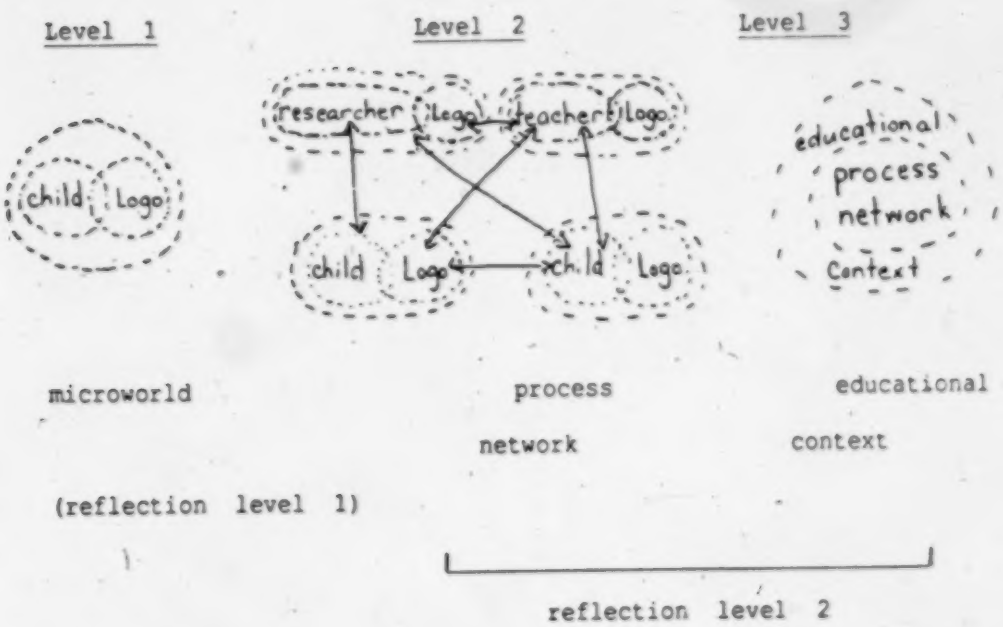


Figure 1: Levels of Reflection

A microworld consists of the interaction between the child and Logo. A process network evolves from the interaction of a microworld with other students', teacher's, or researcher's microworlds. This network is a community of processes generated by constantly changing relationships between components and levels. The process network is encompassed within the educational context to produce a third level of context. Microworlds and process networks are permeable worlds existing within flexible boundaries as indicated by the dotted lines in the diagram.

A Case Study Method

A case study method was seen as appropriate to create a setting in which one can concentrate on children and their experiences and explore the interactive network holistically. A case study allows one to look at the situation holistically and yet permits data collected through a variety of methods to be structured in a life like form. It allows the employment of tacit knowledge which gives "rise to new meanings, new ideas, and new applications of the old" (Stake, 1978, p.6). Stake (1978) contends that a case study is experiential with "its best use... for adding to existing experience and humanistic understanding" (p.7). Stake (1978) also remarks that the case study is an expansionist activity which leads to a proliferation of information rather than a narrowing (p.7).

Since an extended understanding of reflection in Logo contexts was desired through the employment of a variety of research techniques, a case study was felt to fill the requirements.

THE DESIGN OF THE STUDY

The study was conducted in a grade 5 & 6 class in a mid-sized elementary school located in a middle class urban setting. The school had a computer room with 18 Apple II category computers. Classes came to the computer room at scheduled times. The grade 6 students had daily use from 8:45 a.m. until 9:15 a.m. while the grade 5 students came daily from 9:15 a.m. until 9:45 a.m.

I worked with two grade 6 and two grade 5 paired groups. During each period one group was videotaped and both groups were observed. It was anticipated that the groups would be videotaped every second day but in reality there were breaks of several days in some cases because of inservice days, field trips and storms.

As well as videotaping their computer work, I also worked with one grade 5 group and one grade 6 group after their computer time for about 30 minutes. This conference was an extended reflection time in which we would view the videotape of their work that day discussing situations

as they arose. Sometimes these would be problems or sometimes we discussed how and why they did certain things and usually we would try and extend their ideas. I worked with one group a day which resulted in the group having a conference every second computer time.

A two day schedule would be as follows:

Group A videotaped

Group B videotaped and conferenced

Group C videotaped

Group D videotaped and conferenced

Day 1

8:45 - 9:15

Group A videotaped and observed

Group B observed

9:15 - 9:45

Group D videotaped and observed

Group C observed

10:30 - 11:00

Group D conferenced

Day 2

8:45 - 9:15

Group B videotaped and observed

Group A observed

9:15 - 9:45

Group C videotaped and observed

Group D observed

10:30 - 11:00

Group B conferenced

As the study progressed, some trends were developing which I felt should be explored. Thus, at the end of the research period individual interviews were conducted with the participants concerning their feelings about Logo, the projects, working with partners and learning (see Appendix F).

The data were collected over an eight week period from January 23, 1989 to March 17, 1989.

The Logo projects assigned were designed cooperatively by the teacher and the researcher with the final decision being made by the teacher. A variety of challenges were planned, with most being of an open ended nature in accordance with the term "challenge". Students were asked to tessellate a space using rectangles. Later, they were challenged to create a tessellation employing more than one shape (semi-tessellation). A monogram was to be developed using variables in the procedure. Also using variables students were to make a design. A rectangle was

to be divided into four parts as many ways as is possible. The culminating project was the development of a castle (see Appendix A). The same challenge or assignment was given to the entire class with no special treatment for the research groups.

The eight students selected for the study were of mixed ability, willing to participate and familiar with Logo. Because of the computer lab time schedule, it was necessary to have the groups equally divided between the grades. Each grade had 1 group of boys and 1 group of girls.

A descriptive case study method was to supply the form of the study but within this structure several research techniques were utilized to gather data in order to provide "a rich and complex picture" (Mathison,1988,p.15) of reflection in several contexts.

Ethnographic methods of observation were employed in the computer room while the students were working on the computer projects. A limited amount of observation was conducted within the classroom during other times of the day. The observation times were fewer than anticipated because of the arrangement of the timetable, interruptions to the normal classroom schedule and the presence of a student teacher in the classroom.

The technique of stimulated recall was used while conferencing in order gain a better understanding of their reasoning. During this time the videotapes were reviewed with either the students or the researcher being able to pause the tape. Parts of the tapes were played at a faster speed depending on the contents and the needs of the group. This seemed to be an effective way of stimulating the discussion of their actions and problems. In most cases they used the tape to anticipate an action or as a visual starting place to work upon their problems.

In order to keep the conference or reflective time interactive and child centered, it was not prestructured. Flexer (1987) used a clinical interview in which each response of the child determines what the researcher will ask next. The interview questions are contingent on the responses. This method in combination with the elements of a process conference as described by Calkins (1986) were employed throughout the sessions. A process conference involves asking what would be described as research questions which focus on the process involved rather than the product. Before the conference, the researcher would review what the group had done, looking for trends, signs of reflection and difficulties. In this manner, the researcher would have conjured up a starting place for

discussion. Sometimes this did form the seed for exploration while at other times the students had areas they wished to discuss.

A transcribed conference is found in Appendix C.

ANALYSIS OF THE DATA

a) Methods of Reflection

The data, relating to the computer sessions, were examined to disclose methods used by students in reflecting upon the information they had regarding their problem. Once the categories had been isolated, a reexamination was conducted to indicate the frequency of each method. The emergent methods of reflection were:

1. **talk**: The students talked about aspects of the problem with other students, the teacher or the researcher.

2. **write**: The directions for procedures or ideas for future attempts were written down, usually in their computer books. This category also included jottings or calculations.

3. **draw**: Diagrams or rough sketches which assisted in solution attempts were drawn.

4. **moves**: The students moved parts of their bodies, usually fingers and hands, or moved their computer book around, or counted items. In each case, part of the body was moved to derive information about the direction the turtle should be moved or the distance to be moved.

5. **textscreen**: Commands were used to show the "textscreen" which displays a greater number of previous commands than the normal number displayed on the "split screen". This category also included the return to splitscreen if the students had been using the "fullscreen" where no commands are displayed.

6. **previous work**: Students referred to work which had been done earlier.

7. **edit**: Work was examined line by line so that each step of a procedure could be contemplated. This method was employed in three versions:

i) **E** was editing line by line in the immediate mode. Nothing was saved to disk but each command produced a graphic display which could be scrutinized.

ii) **Ee** was the line by line examination of a procedure which had been saved and was in the Logo editor. This was achieved by checking instructions; or by trying the

procedure out one command at a time; or by representing each command on paper as a comparison.

iii) **Epu** was editing done line by line with the pen up so that inaccuracies needn't be erased. A procedure could be checked out before anything became permanent.

8. **GCA**: This method involved guessing; checking by trying it out; and then making adjustments to one's attempts. Information obtained was subsequently used in refining the guesses.

9. **GCAexp**: Experimentation was a strategy used to reflect upon a problem. Using this method, guesses were attempted and adjustments made until the students had devised a theory for solution, whereupon they would switch to another method.

10. **long wait**: This method involved no overt action. Students might have fiddled with the keyboard, drummed their fingers or stared at the screen or into space but there was no specific action indicator. The result of the reflection was an attempt to solve the problem.

11. **go to something else**: Participants left the problem and worked on something else.

12. **direction**: When working with graphics in Logo, the graphic may be clearer if the turtle is hidden using the

"hideturtle" command. In these cases, students used the "showturtle" command to reflect upon the turtle's directionality.

b) **Researcher's Comments**

The researcher's comments during computer times and conferences were classified regarding intent. The classificatons were:

1. **probe**: Questions were asked or statements made in order to have the participants intensify their exploration of an idea.

2. **tell**: Information was given.

3. **explain**: The researcher explained the reasoning behind concepts.

4. **suggest**: The researcher made suggestions for future action.

5. **re**: Statements were made which reinforced the student's action or thought.

6. **search**: During a search, the researcher's comments were directed towards uncovering the problem area.

7. **model**: The researcher was attempting to demonstrate a method of reflection which the participants might use in a similar situation.

Graphs indicating the distribution of these types of comments in various situations are found in Appendix D.

c) **Frustration**

It became apparent that some groups and/or individuals were becoming frustrated. Consequently, indications of frustration were identified for each group. These signs were words "I hate this computer!" or actions such as hitting the keys which suggested the individual's rising frustration. A tabulation of these frustrations is located in Appendix E.

d) **Follow-up to the researcher's comments**

Analysis was also completed to link researcher intervention with subsequent student work. Since the number of researcher comments during computer sessions were low, the comments and direct follow-up situations were counted and expressed as a ratio. (e.g. see page 55)

A listing of the intervention and its follow-up was made for the researcher's comments during conferences.

THE ROLE OF THE RESEARCHER

In the computer classroom the researcher was an observer participant. Her main role was as observer. Participation was forthcoming if the researcher was approached or if the students became extremely frustrated but in this setting participation was not actively sought. When participation occurred, the researcher attempted to encourage the students to reexamine their thinking through the use of probing questions or suggestions.

On the other hand, in the conference group the researcher sought to become a participating member of the group. At the outset the researcher had built in authority over the situation through control of time and equipment and taking responsibility for the stimulation of the discussion but it was thought that this authority would not be inhibiting and as time went on there would be three learners working on a problem.

The researcher's role with the teacher was one of cooperation. Students were presented with challenges designed by the teacher working with the researcher. Discussions were held informally about the observations and ideas arising from the research. These discussions led to a clearer understanding of the children.

CHAPTER FOUR

CASE STUDIES

The case studies of the four groups will be presented with the cases of the two groups not being conferenced given first.

Case One: Jean and Karen

(not conferenced)

As the Logo experience progressed, Jean a grade 6 student, drew diagrams and figured out instructions in her book. At first she appeared to have a plan but didn't write it down. Her systematic planning began to appear on paper, helping to organize her thoughts. She had a good sense of humour, usually seeing something good or humourous even in misadventures. When attempting to colour their checkerboard and the background became white she laughed and commented "well it is black and white!". Another time when the shape did not appear as expected she commented "well that's kind of cute". She took most upsets in stride and normally proceded to examine other directions. She usually had tried many methods of solution and thinking before she became frustrated. She maintained good peer relationships by demonstrating an interest in other students' work, assisting them and always having

positive comments for others. She was self assured and worked towards her own goals. Being proud of the fact that she had solved something, several times she wanted to show me in the spirit of sharing rather than an attempt for attention. In explaining her reasons for working alone, she said "you have no one else to blame". Being self assured, she was willing to take responsibility for her actions. "You feel little when the teacher tells you what to do (but) when it's a challenge you feel more responsible." The sense of accomplishment felt in working with a challenge was a prominent theme in her conversation. Jean was confident of her ability to solve challenging Logo problems, having a preference for projects which allowed for originality, which required thinking, and which required decisions about how to solve them.

She was very patient with her partner. At times when Karen would become upset, Jean would ask questions to get her going in the right direction or would keep on trying herself until they had a solution and Karen's mood had changed.

Karen, a grade 6 student, tended to begin working without a plan or with a partial plan and to sort things out along the way. She was an enthusiastic Logo user who applied herself to solving the problems but became frustrated if the solution seemed elusive. When frustrated,

she had a difficult time seeing her way to using a strategy to solve the problem. Several times she refused to go into edit mode until Jean or I insisted because "that's what we did" or "This is exactly what I have in the editor. I keep doing it ....and it comes out wrong". But each time when the problem had been sorted out, she immediately got started on the next thing.

"I was having trouble with the castle wall and I asked Jean. She went over it and found the problem".

At this point, they began working through the procedure and eventually found a solution. Karen became upset several more times but was coached into participating by her partner. As soon as they had built the wall, she was ready for the next challenge.

K "okay,....tower."

J "Do you want a pointy top?"

K "Yes, a pointy top."

J "It has to be taller than 160. How much? 180?"

K "We have to see where it ends."

With the problem settled, it was back to regular business. She was appreciative of Jean's help and

recognized it as a time when talking to someone helped in solving a problem.

Although Karen became frustrated when a solution was not readily available, she had a preference for challenging assignments since "it's not that much fun doing easy stuff that you already know how to do" and the accomplishment felt good "because then I know I can go on to something harder".

[Remark: Perhaps part of her frustration came from a gap between her expectations and achievement. She often insisted that she was right but on March 14 she seemed to be insisting that she was right about something. Of course, another possibility could be that she operated in this manner in other situations and it was not an inhibiting frustration in that she had learned to make compensations.]

Jean and Karen have been friends for several years and felt they worked well together. In particular they appeared to be aware of each other's strengths and tolerant of each other's actions. This relationship influenced their manner of working. At first they worked together on their projects but after several weeks they began to work separately on the days they were not

being taped and this pattern continued until the end of the research period. Differing ideas and the desire to try their own ideas without imposing on the other person were reasons for moving to separate computers.

Reflection

Jean and Karen used three types of reflection while they were working. They talked, examined the problem or parts of the problem, or turned their attention to something else. Talking involved mostly talking with or questioning each other, talking through the instructions either on the screen or in a book, or discussing with an adult. Methods used to examine the problem were writing instructions or ideas, drawing sketches, moving parts of the body, checking turtle direction, checking the commands either through the use of textscreen or in the editor, or through a process of guess - check - adjust. When Jean and Karen turned their attention to something else they experimented with ideas until they had a plan to be tested through the guess - check - adjust route. On Jan. 24 they experimented with the colour 3 times and then went to the editor to use this information in their procedure. Sometimes as on Feb. 10, in changing from an octagon to a triangle, they chose to try the idea with a different shape. In some cases, they decided to try a

new project with the idea of returning when they could see the solution more clearly.

The method that Jean and Karen used most often to work out their solutions was guess - check - adjust (see fig.3 pg.109). This was closely followed by talking. Experimenting with ideas was popular. They also relied heavily on editing line by line in the immediate mode. Jean and Karen did not rely to any extent on writing commands to reflect upon but rather would check the textscreen to check commands. Beginning part way through the study, they did use drawings as a guide and utilized finger, book, and body moves and those involving counting in determining a direction, angle or distance to move. Other methods used were referring to previous work, editing line by line in the editor, working with the penup, checking the turtle for direction and going on to something else.

The reflective methods that Jean was aware of using were planning in order to decide on the easiest or main thing to do; looking for a pattern or change in the editor; using grid paper; and following through each command. After these she would ask someone and if she still did not solve the problem she would "go on to a different project or save it and try when we get another idea".

Karen thought that going to the edit mode was the best strategy but also drawing in a book and getting directions from grid paper helped in deciding one's next step in a problem. If she was stuck, Karen would ask a friend because "sometimes they look at it in a different way: you can't see it but they can". She also felt that trying something different helped one see the problem in a different way because "when you come back you know what your problem is because you see it right away".

Context

a) microworld

Being in pairs at the computer greatly influenced the structure and development of the individual's microworld. The framework that they imposed on their working conditions structured their interaction with Logo.

Jean's role was characterized by many of the roles of an observer. She was participating on a different level from her partner who was at the keyboard the majority of the time. She gave instructions for procedures and made suggestions for action which would be acted upon by her partner. The following instance on Jan. 26 exemplified her desire to use Logo features:

J "we have to make this into a procedure"

to checker

K "call it another name - How about colours?"

to colours

J "We could call it check with a k "

(Karen uses this suggestion)

to check
chec

J "we should use a repeat"

K "no because it would do it all one colour (repeat the same thing)"

J "no just repeat how many times----"

K "We might as well do it this way because it's easy to use control R"

J "okay"

(they used Karen's plan this time)

She liked to work with Logo at the procedural level and after the initial working out of an idea she would suggest making a procedure. Suggestions were also made to incorporate other features of Logo such as using a repeat.

Another characteristic of Jean's microworld was her use of line by line editing. She was quite systematic in her approach to a problem whether the instructions were followed through with her finger on the screen, by moving the book around or by following the line with her eye. This concentration on the commands when confronted with a problem accented her belief that any problem was with the instructions rather than the computer. This realization of her relationship to Logo appears to have developed during the study. Jean's indications of frustration (13) (see Appendix E) were concentrated in the first three sessions with four of these being remarks directed at the computer. On Feb. 10 she exclaimed "It's the computer.....It just won't work. Stupid computer!". From these remarks she worked her way through many problems in a systematic way and in the final interview indicated that one advantage of working alone was that "you don't have anyone else to blame". Jean's interaction with Logo had evolved into an orderly and workable relationship.

Since Karen was in control of the keyboard almost all of the time, she was the primary connection with Logo. Her initial encounters with Logo appeared to be experimental with the use of drawings for planning only being introduced near the later part of the study. On Feb. 10 she kept experimenting with the number of repeats, while

on March 2 she experimented with an "increasing size" pattern of stairs. In a procedure employing a variable, she tried out many different sizes of decimals as an input. She would often experiment with ideas or just begin, while Jean was planning. Remarks such as "I keep doing it the way I wrote it and it comes out wrong." and her insistence that "the computer is not working" did not indicate a belief in her command of the situation. Karen seemed to believe that the computer had a mind of its own when it didn't do what she had intended. In addition, when she encountered problems with a procedure she did not attack the problem as if she had control. Instead she muttered and complained, becoming involved in her frustration, attempting haphazard changes and random keyboarding, which didn't result in a solution. On March 14 while making a castle wall (assignment 7, see Appendix A), she was putting in what Jean said:

J "Wrong it should be lt 90."

K (changes it) "see if this works."

```
fd 20 *:s lt 90
fd 20 *:s lt 90
fd 20 *:s rt 90
fd 20 *:s rt 90
fd 140 *:s rt 90
```

end

cs

wall 1 (the wall has an extra twist in it)

J "oops we didn't....."

K "It didn't work"

J "It's not in the right place."

K "Well it doesn't work anyway."

K (mumbling) "We'll see. You think that's the problem.....I was right it should be right 180."

cs setup wall 1 (half of the wall is right and then it goes the wrong direction)

J "right about what? rt 180 and lt 90 are the same thing"

K "so....I was right"

J "What difference does it make? Let's edit. We're facing this way...."

Even when Jean pointed out that they hadn't put the instructions in the correct place, Karen was reluctant to accept this reason: it must be the machine not her.

Later that day she again indicated that she did not feel in control.

J "Don't put home it'll go there all the time!"

[[J is quite insistant but K keeps on]]

J "Don't put home"

K "Why?"

J "You don't need it and home usually screws things up"

cs
wall 1 (wall and move)

[[K typed the wrong thing and was getting frustrated. She muttered "come on...come on" "oh no not you" (wrong procedure) and then struck the keys harder and harder]]

J "See you don't need home in there"

K "But I put it in!"

Since she showed indications of frustration 38 times during the study (see Appendix E), her interaction with Logo appeared to produce frustration. Although frustration existed it did not seem to have any long term effects on Karen's willingness to work with Logo. Karen's interaction with Logo could be characterized as impulsive with some signs that planning in the form of drawing was

beginning to take place. Examination of her notebook indicates that she began to make some diagrams when making letters (assignment #3 - see Appendix A) and to write down some instructions for the last assignment. This may have indicated the beginning of a move away from the impulsive relationship apparent at the time of the study.

b) process network - student/student

The interaction between Jean's orderly microworld and Karen's more impulsive one produced a working relationship which they felt suited their needs. Since Karen spent most of her time at the keyboard, she made the final decision on any action. Selection of ideas seemed to be fairly evenly divided between the partners. Although Jean's role was primarily to make suggestions or ask questions, she was insistent if she thought she was being ignored.

This process network was built out of the discussion of ideas. Karen and Jean did not rely on writing or drawing to generate their ideas: they used words. They discussed ideas almost as much as they used the guess - check - adapt method of reflection. They made suggestions:

K "It just needs to be turned 45."

J "It's too small."

They confirmed actions:

J "This should be pink, right?"

They talked their way through commands either in the initial stage or to confirm the instructions.

They asked questions:

K "What shall we call it?"

or

J "It has to be taller than 160. How much? 180?

For Jean and Karen the main component of the network was the generation of ideas through discussion.

The production of interaction between the two microworlds also permitted Jean to assist Karen. This was evident on March 14 at the beginning of the period when Karen was upset.

[[K is always sure she didn't do anything wrong and won't check until someone else insists. This time it is J]]

K "It's my wall - not any windows"

J "You're not turning left"

K "Yes I am. This is my whole procedure. You try to follow it"

J "put it on editor and we'll see. I'll follow it."

K "this is exactly what I have in the editor."

J "maybe not"

K "I keep doing it just the way I wrote it and it comes out wrong."

J "It could be wrong"

K "I did that wall and wrote it down

J "and that's what you keep getting"

cs
wall 1

J "that's good. I should see it first"

cs setup wall 1 (on the 4th bump it goes down and back instead of up)

J "Well you get a nice.....oh!"

K "It's this last one."

J "No problem. Let's go to the editor. Tell me what you've got"

K "fd 20"

J "I don't know the variable"

K "they're 20 apiece"

(talk and nod)

ed "wall

J "so tell me what you've got"

(Karen reads it and Jean checks it)

By being tolerant and employing her systematic methods, Jean involved Karen in solving the problem which had been causing Karen difficulties.

Their process network provided the opportunity for the modelling of strategies, as indicated in the above incident. Jean used line by line editing to uncover the mistake and she assigned Karen a role in this process. She continued to use line by line checking throughout the day until they found a solution but she also modelled turning the book for directional clues.

K "These 3 are working"

J "Just a sec"

K "yes because if you're going right"

J "just wait" [turning the book]

J "so it goes this way."

J "Wrong it should be lt 90."

fd 20 *:S lt 90

fd 20 *:s lt 90

fd 20 *:s rt 90

fd 20 *:s lt 90 (changed rt to lt)

K (changes it) "see if this works."

This network produced and allowed for the development of a variety of working arrangements. Jean and Karen both stated that an advantage of working with someone else was the opportunity to have two sets of ideas but that you must also be willing to try someone else's ideas. This conflict of purposes led them to begin working at separate computers on the days they were not being taped. Jean explained "we had different ideas and couldn't decide which one to try so we just went to different computers." Although they were working on separate projects they continued to consult each other. Cooperation characterized their relationship. Even if they worked on separate ideas they consulted each other, assisted each other and shared thoughts. In this case the advantages of being able "to use your own ideas" and not "having to get your partner to agree" seemed to outweigh the advantage of "having two people to think".

Opportunities for discussion, assistance and an openness which provided for alternative working arrangements, characterized Karen and Jean's evolving network.

c) process network - student/student/researcher

The network produced by the inclusion of the researcher was limited because of her desire to restrict involvement. The researcher was asked for information twice on Feb. 27 and March 14. The students also wanted to show the researcher solutions they had discovered in her absence.

In the times that the researcher became a part of the process network, there was follow up of the ideas suggested 5 of the 7 times, which indicated that the suggestions were considered and taken seriously. In analysing the researcher's comments, 6 were considered suggestions, 6 telling information, 5 were reconfirming statements, 3 were probing questions, 3 involved a search, and 1 was discussing (see Appendix D). The researcher's role was one of answering questions, encouraging the participants, and inviting the pursuit of new ideas.

Was a viable process network developing in this situation? Yes, in that the researcher appeared to be recognized as a knowledgable person to approach for assistance, a person with whom to celebrate successes, and a person whose ideas were worth trying.

Case Two: Ross and Simon

(not conferenced)

Ross, a grade 5 student, was considered to be a fast typist. Observation verified this fact but also indicated that he was not particularily accurate, a fact which caused many frustrations at the computer. Most of his frustrations resulted from carelessness and were directed at the computer (see Appendix E). Ross admitted to having some upset feelings generated by working with his partner but generally he had a happy, carefree attitude exemplified by giggling, laughing and joking.

Ro "Simon I got it!"

S "Now we can do the other line. What's the procedure?"

Ro "I forgot"

R "What are you going to set it at to go down?"

After working through the idea again.....

?SETH 0 (Ross remembers and does it)

?CS

?SETUP REC 3 RT 56.4 FD 286 (rectangle and purple diagonal)

This situation was typical of Ross's hurried behaviour. He had been assisted in obtaining a solution but forgot the idea and then required intervention to discover again the

idea that led to his solution. Ross tended to do everything quickly, charging headlong into things without thinking or planning. He would begin experimenting immediately without any discussion with his partner, even while his partner was devising a plan. He often gave the appearance of being in a hurry, stopping procedures in the middle, after seeing only a part. In addition he used ERALL and CS in a reckless fashion, erasing everything before he had thought about the situation. A typical example occurred on Jan. 24 when he became confused and erased the procedure without discovering that he had been editing the wrong procedure. He kept trying things but was too rushed to contemplate the reason for an action.

Speed combined with a lack of concern over commands accented his orientation towards the value of quantity and product A preference for the castle project because he "likes those kinds of stuff....knights and everything" and his inability to think of a reason for feeling the rectangle assignment was boring highlighted an emphasis on product rather than understanding. He was the only participant who didn't have a reason for favouring a project that was " creative or challenging". He was concerned with the looks. In addition when the word "challenge" was mentioned, his mental connection was not

with puzzles or figuring things out but with a video game having a speed challenge.

Ross was a spontaneous worker: "a picture in his brain" being his only plan. His belief, that working with another person was necessitated by the need to have someone else write things down, indicated that for Ross planning and doing are separate entities. His role was to "do".

Ross "fiddled and diddled around" and this experimentation characterized his approach to Logo. Fast impulsive reactions were his trademarks.

Simon, Ross's partner, a planner who thinks before attempting things, wrote ideas and commands down in his book. He was serious about his work - quiet but determined. He often pushed Ross away from the keyboard if he would not listen or try an idea. Simon wanted to figure things out before commencing work, doing so even if Ross went ahead. "Let's make a procedure ": these words expressed Simon's desire to transform ideas into procedures and highlighted his organization. On Jan. 23, Jan. 25, Feb. 2 and March 8, he pushed for making a procedure rather than trying again in immediate mode. Simon's actions were deliberate and calculated.

Ross and Simon were friends but they did not always have a smooth time working together at the computer. "I just took the keyboard away from Ross and typed it in anyway". This was how Simon handled Ross because "he was fooling around and we had different ideas". Simon was not upset by this behaviour because Ross is like that in other things so he is used to it and knows what to do. Simon has adapted to working with Ross.

Ross was much more emotional about the situation. He sometimes felt "yucky" or upset because they were fighting over ideas. "We fought lots" but " sometimes I used my idea and sometimes I used his". He adapted to the situation by compromising.

Because of Ross's fast typing, he was always at the keyboard while Simon wrote and planned. Ross made the decisions on what action would be taken. This occurred to such an extent that Simon resorted to removing him from control such as on Feb. 15:

[Ross is fooling around. Simon wants to do something but Ross is just putting down anything.]

(Simon takes over the keyboard)

TO L :SIZE

(Ross keeps trying to press the keys. Simon is becoming upset)

```
FD 10 * :SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE RT 90
FD 6 *: SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 *: SIZE RT 90
END

?SETPC 5
?L
?L 2        (cross)
```

or March 8:

[Simon has an idea but Ross continues with his idea until Simon pushes him away to use the keyboard]

[Simon calculates numbers in his head but then begins to write them on paper]

```
?HT
?ST
?CS
?SETUP REC
?RT 56.0
```

?FD 286 (closer)

They continued to work in pairs but had adapted to the situation by adopting set roles and making adjustments to their behaviour.

Reflection

Almost exclusively, Ross and Simon, adopted measures which directly examined the problem or parts of the problem. They did some talking which involved discussing an idea, questioning their partner and asking another student for help, but unlike Jean and Karen, very little use was made of talking through the commands or discussing plans. One line statements or instructions were given to which their partner rarely responded verbally. Although they both gave "quitting and going on to another project" as a strategy, they only did this 3 times.

As with other groups, the most common reflective strategy was to guess - check - adjust (see fig.4 pg.110). Ross and Simon's second most common strategy was to use ST (showturtle) to check the directionality of the turtle. This was not a popular method of reflection with other groups but perhaps it was related to the fact that they began to work more and more in the immediate mode rather than making use of procedures. They rarely edited procedures line by line, using line by line editing only

in the immediate mode. Other methods of reflection employed by Ross and Simon were writing, drawing, and experimenting. They also used a category which I called a long wait. During this time no observable strategy is used - sometimes there was a drumming of fingers or staring at the screen but the result of this wait was another try.

The methods of reflection that the boys were aware of using were limited to "figuring something out on the computer", "looking at the posters with instructions" and "fooling around to try to get close".

[[remark: This lack of direction appeared to be one of the problems they had in attacking problems in Logo.]]

Context

a) microworld

Their working arrangement did formulate their relationship with Logo but because of their tendency to work alone while together, it may not be as strong an influence as with other groups.

Because of Ross's position at the keyboard he was the primary link with Logo and controlled most of the interaction. His relationship could be characterized as

impulsive. His encounters were experimental using the immediate mode: he tried ideas quickly, clearing rejects before they could be analysed. He had a lot of difficulty doing things in the edit mode because it was not operating in the manner he expected. He didn't ask for help: ceasing use and operating mostly in the immediate mode seemed to be his reaction to this lack of understanding of "edit". Growth in his approach to Logo or the development of an enriching microworld were not discernible. His direct approach of no writing and going directly from the picture in his mind to the screen combined with the fact that he didn't usually talk to anyone about the problems indicated a limited interaction with Logo which may be connected to his lack of control within Logo. Logo was something to give him answers not a medium to work with in solving problems. He didn't have a feeling for Logo functioning and he didn't trust it. He kept checking to see if procedures existed and were accessible because often there was nothing in the editor due to his incomplete commands. Also, designating procedure names having no connection to the shape or manoever, indicated a lack of understanding of the interconnectedness of ideas in a Logo microworld. He made comments of frustration about the product but not the computer such as "this is crappy" or "Look at this

crooked thing". Perhaps he hadn't thought of Logo as an assistant.

Simon's relationship developed at a distance. Except when he took over the keyboard forcefully his role was of planner and organizer. He concentrated on writing and drawing. He liked to have the procedures worked out before he began and on Feb. 8 and March 9 he had his ideas worked out in his book when class started. He didn't display any signs of frustration with the computer, in fact, there is no indicator of his understanding of the capacity of Logo except that he trusted the saved procedures to be there and didn't think Ross needed to keep checking. Simon's microworld did not show signs of evolution. It was an organized world depending on underdeveloped strategies and a limited understanding of the potential of the language.

b) process network student/student

The network resulting from the interaction of Ross's and Simon's microworlds did not appear to assist them in dealing with Logo. Mechanisms which might have blended Ross's impulsive microworld with Simon's highly organized one were not evoked. Communication would be one technique.

"I'm changing all the lt's to rt's" or "Just put in anything" are typical of the isolated comments made which

received no response from the other person. Words were scarce: communication almost nonexistent.

Ro "Now what are we going to make?"

S "I have an idea."

Simon begins to work but doesn't say anything so Ross begins to experiment on the screen.

This exerpt from March 13th exemplifies the dearth of communication between the partners. They didn't discuss ideas: rather they proposed their ideas or gave instructions and then acted. Their interaction doesn't appear to have assisted in the development of a process network. The general lack of communication is accented by the success they experienced on March 9th when they worked closely together.

They began by putting up the solution from the previous day.

S has the next procedures worked out and written in his book.

They made the rectangle with 2 diagonal lines and 2 parts coloured with a border.

They were very proud of this and called me over to show me what they had done.

[R made a suggestion of what to do next and S made another one. They try S's]

Partway through, R says "no it's like this - we want to go through the middle"

S starts doodling in his book until R asks him how far to move the turtle.

* They work through step by step to check.

The cooperation that they experienced in this instance was short lived. Usually there was no coordination of planning: they carried on their own business, while Simon planned in his book beside Ross at the computer. Ross' remark that "using a procedure makes it even more confusing" highlighted the growing confusion they were experiencing with Logo. Their misconceptions were not resolved and became a roadblock to their progress. They began the Logo sessions confidently using procedures but running into problems with the "edit" mode could have shaken their confidence, resulting in an increased use of the immediate mode. They had difficulties operating in the edit mode because they had misunderstood its capabilities and by Feb.15th they had begun increased operation in the immediate mode.

[[Remark: Since they didn't seem to be able to discuss the problem and come up with a solution or even ask for help, the problem remained and festered.]]

The lack of communication and collaboration did not allow for the development of a synergetic relationship. Opportunities for the partners to learn from each other's styles did not arise in the resultant network.

The Logo world experienced by Simon amd Ross appeared to be static and unrewarding.

c) process network - student/student/researcher

The researcher limited interaction at this level. Ross and Simon did not elicit information but on March 9 the researcher was called and shown their rectangle with 2 diagonals. The researcher did most of the initiating of interaction, such as when they looked puzzled by computer remarks, as on Jan. 23 and 24. The researcher's remarks were mainly of a probing type (12) with suggesting (8), reaffirming statements (6) and explaining (4) also taking place (see Appendix D). There was followup of ideas, prompted by the researcher, 14 out of 17 times. Comments by the researcher were intended to facilitate and focus thought on the problem subject.

Case Three: Anna and Susan

(conferenced)

Susan was figuring out the angles on paper while Anna tried one procedure at a time to find out which command had to be changed. This scene typified the girls' approach to Logo problem solving: collaboration. In contrast to other groups Anna and Susan grade 5 students, had similar attitudes and approaches to solving problems with Logo. Susan, a planner, found satisfaction in figuring things out. She liked the sense of accomplishment felt after trying, figuring and then getting a solution. Her goal of solving the problem, was worked on in computer time, spare time, home time or in the conference time. Often she was so involved with the project that she worked on an idea while glancing at the videoplayback just to keep track of the happenings. This frequent occurrence was most obvious on Feb. 27 when she came prepared to discuss the difficulties they were having making a cross design (assignment #5 - see Appendix A). She fiddled, asked questions, and adjusted until the videotape was abandoned and the problem became the focus. Susan stated many times that she wanted to use her own ideas. In fact, she and her partner seemed to make a concerted effort to be different: in doing the rectangle tessellation they made it look like a brick wall rather than rows of rectangles; they chose a pentagon to semitessellate

(assignment #2 - see Appendix A) because they didn't want the same shape the teacher had been talking about; they tried their own ideas of dividing the rectangle into parts which involved many more divisions than requested; and the letters (assignment #3 - Appendix A) were a favourite because "you can do lots of things with them".

Susan had a definite opinion on independent working. A March 6th conversation illustrated this opinion.

A "But sometimes we like to do our own."

R "So you like to do your own thing better."

A&S "Yes"

R "Why, do you have any idea why you like doing that?"

A "Cause you pick."

S "You can pick your own things without the teacher saying 'OK, now you do this and then you do this'"

Susan was not appreciative of being told procedures. She felt strongly about the importance of being able to use her own ideas and, as well, the importance of being able to work out the process herself.

R "Do you think that you learn as much in assignments when you are not told exactly what to do?"

S "That depends, if you are just fooling around and drawing lines on the screen, you are not learning much. (But) like me and Anna were making S's already, naming letters, and we were learning. "

R "So you think you were learning a lot when you picked out the letters that you wanted to do and what you wanted to do with them. As much as you might learn from doing this (dividing the rectangle)?"

A "Yeah"

S "Or maybe even more"

R "Do you have any idea of why it might be even more?"

S "Because this one, he told us how to do these things and he already put it into the computer."

(discussion about making procedures and fixing them)

S "You can learn from your mistakes. This thing we're not really learning things because all we have to do is type in the name of it."

As illustrated by the above conversation, Susan and her partner were upset by the assignment of dividing the rectangle: it was too easy; it didn't allow creativity; it was prescriptive; and Susan felt that it didn't allow

for learning. They needed to work things out for themselves in order to learn. Someone else could facilitate learning but they would have to integrate showing and telling. Susan summarized "talking helps me but its even better if they show me and are telling me at the same time. Like here we do this and this."

[[Remark: She kept emphasizing the difference between showing and telling. It wasn't enough to just tell: it must be connected with showing. They stressed that someone else doing it for you even if they verbally explained the action was ineffective.]]

Susan's approach to solving Logo problems accentuated her independent nature and her stated desire to learn by herself. Her systematic approach consisted of drawing, writing commands in her book, trying out the plan both on the screen and in her book line by line, and making adjustments. Planning ahead, either while Anna was typing in the previous commands or in her spare classroom time or at home, was part of her system. An examination of her computer book showed that she had a diagram, procedures and calculations for each project.

Susan, an independent, hardworking, cheerful, systematic planner, felt that learning is an individual matter which can be assisted but the learner must be involved.

Anna enjoyed working with Logo because it was a "challenge". She liked to figure things out in projects of her own selection which allowed her to use her own ideas. She demonstrated extreme frustration with the most prescriptive assignment involving division of a rectangle but she quickly changed the project to involve a large number of divisions, thus increasing the challenge of the assignment.

R "Do you have any idea why it might be more (that you are learning)?"

A (angrily) "We didn't even get to make our own procedure!"

R "Oh, so you don't even get to do that. So you might learn more when you have to make your own procedure?"

A "Yeah. It was fun because you mess up and it looks funny what you did."

Her remarks concerning the rectangle assignment indicated that she was insulted by a project in which she wasn't even allowed to make the procedure which was the process by which she felt she learned: "when we do something, then we are figuring it out ourselves and then we remember it more."

Her approach to solving Logo problems was very efficient. She formulated plans ahead of time, edited line by line and made use of the penup provision in order "see if the plan is going to work". Sometimes she experimented with ideas at the computer in order to develop a plan. She felt that it was important to discuss ideas and always liked to "ask someone what they think".

Anna, a planner, enjoyed solving problems which were a challenge.

Anna and Susan have been friends for six years and they got along well. Anna worked at the keyboard while Susan wrote and drew. This arrangement was agreed upon because Susan was slow at typing and Anna was slow at writing since "she is too neat". Their working arrangement resulted in a collaborative relationship in which both members gave ideas freely. They spent a lot of time discussing ideas and planning their moves. Although Susan commented that Anna didn't always tell her what she was doing, Anna did ask Susan for information and suggestions.

Reflection

The types of reflection employed by Anna and Susan were talking and looking at the problem or parts of it. They discussed ideas together or with the researcher, asked

each other questions, and talked through the instructions. They used guess - check - adapt and experimenting to almost the same extent. They edited line by line in the immediate mode, talked and checked the directionality of the turtle.

Anna and Susan's usage of reflective methods was high (see fig.5 pg.110). They made extensive use of guess - check - adapt and experimenting but they also employed editing line by line with the penup. This was the only group to make extensive use of the penup feature in editing. Editing line by line occurred in the immediate mode but not in the editor. Turtle directionality was checked by using showturtle and hideturtle commands. The heavy use of experimenting, editing line by line, finding the turtle's direction and editing with the penup indicated their tendency to plan and sort things out before making a procedure. They were very careful, precise workers who wanted to have it right before making it more permanent in the form of a procedure.

Talking was a reflective method they used in solving their problems. Most of this talking was in the form of discussing future directions and asking their partner's opinion.

Other prominent strategies were writing and drawing. Diagrams were the basis of their planning in every

project. On the other hand little use was made of the textscreen to check the instructions because they had the commands in full view in their books. Turtle direction or the amount of angle was verified by moving the book or their hands.

Earlier procedures were often examined for relevant features. They made use of the procedure for making F when planning E and they referred to earlier work when trying to decide on the angles in a shape.

The reflective methods that Anna thought were important were referring to previous work; guess and check especially to determine an angle; and talking to someone else.

Susan listed many techniques that she would use: all of which were used frequently in their work. She would move the book around, use her finger to measure or point, use her hand to show the angle direction, go to the editor and do one step at a time. She would also guess and check because "you can tell if it needs to be more or less", try it with the penup, talk to her partner, draw a picture or use the squares on the grid paper to figure out some things.

Context

a) microworld

Both Anna and Susan had a clear understanding of the control they have in the Logo world. After a conversation about math and computer problems, I asked:

"Is there something you don't like about the computer?"

S "Sometimes you can mess up and you don't know what you are doing wrong. Or you could lose something."

R "Oh, so if it just disappears, you haven't saved it the right way or something like that. But is it the computer you really hate?"

A&S "No it's us we're just blaming it on the computer."

Their systematic approach to solving problems reinforced their belief in the reliability of Logo: if one goes about one's work in a careful way, Logo responds as expected.

Both Susan and Anna had logical, planned and regular interaction with Logo. They had a plan ahead of time, they tried this plan out, refined it and finally made a procedure which may require further refinements. They regularly took advantage of Logo features such as showing

the turtle, penup, and the ability to show line by line graphic displays to assist in their development of problem solutions..

Since Susan was not at the keyboard, her interaction with Logo was indirect. She was most often dealing with ideas in written form which then had to be translated before direct contact with Logo. Although she was a step away from direct interaction, she dealt extremely well with Logo ideas at this intermediate level. Using book and body movements she determined turtle moves. She was able to translate commands into diagrams while doing line by line editing, thereby relating with Logo in another form. At the same time that Anna was using the computer to figure out which procedure needed to be adjusted, Susan was figuring out the angles in her book.

Anna's position at the keyboard gave her direct contact with Logo and this affected her interaction. Although she liked to work from plans, she was willing to experiment in order to devise or refine a plan. The castle assignment provided opportunities for experimentation. She contributed ideas to the written and drawn plan but before it was complete she began building a wall on the computer which was later incorporated into the plan.

The microworlds developed by both Anna and Susan were based on regular, logical interaction but through their positions at the computer, Susan's world had a theoretical character while Anna's was more concrete and reliant on the computer.

b) process network - student/student

The process network developed through the interaction of Anna's and Susan's microworlds was a vibrant evolving world. Their network developed through collaboration with talk being instrumental in its evolution. Almost all of their talk was between themselves and consisted of discussion of ideas, questioning each other, and talking through the instructions. Talking generated new ideas such as the realization that numbers are multiplied with a variable and adjustments might need to be made when using a procedure within a procedure.

A "It looks right up to here."

A "This part where we have 13 - it would be one half of 13 because in this part we did 2 and 2."

S "Why not use 13?"

A "Well, when we put CROSS 2 it's going to double 13 so we need to put one half of 13.:.....get it?"

S "Yeah, I think so."

Talking also developed or clarified ideas when difficult moves were involved

A "How much maybe 12"

S "Well let's figure it out - 1.41 times. We did something with the size of the line and this number. Remember if you have this side and this one you can figure out the other one. We only want this one."

[Anna uses her fingers to measure the amount of space]

A "Okay how does that look?"

[She used the guess - check - adjust method to try to find the length of the side]

?FD 13 (it touches)

S "Good guess"

?HT

?FD 13 (goes past the line)

A "No it's not the same"

?PE BK 13

S "If this is 10 (line) then this line must be 10 but at a different angle"

A "It's how much?"

R "Well that's better"

S "I'd say off 1."

A "That's 9. Why not make it 10."

or new ideas.

S "Don't you need it in cross"

A "I did it in cross"

S "but just put * :si"

A "like that"

In these cases the discussion led to an extension of an idea which would not have been as fully developed without the verbal intercourse.

On March 2, Susan realized that their cross star could not be rotated radially because they had used a setheading command and it would go out of shape. From her calculations on paper, Susan understood and tried to explain it to Anna and the researcher who were at the computer and did not recognize the difficulty. Thus, another dimension was added to their relationship with Logo by the use of two mediums of operation; paper and

the computer. Anna and Susan did similar types of actions in their interaction with Logo: one at the keyboard, the other on paper. The combination of these two experiences added another dimension to the process network. Utilization of a second reflective medium enriched the network through providing for the resolution of a problem by viewing it from a different perspective.

The use of two mediums provided the opportunity for verifications to be done simultaneously.

[Susan writes down the instructions as Anna tries it. Anna checks the instructions with Susan.]

[Susan gives instructions from her book and follows in the book on the diagram as they go along]

[In planning the spaces Anna used her finger to estimate the distance and then checked with Susan]

Confirmation of this type was used throughout their experience.

Through the collaboration of the partners, the network was also enhanced by its resultant efficiency. In making the letters (assignment #3) Susan was planning the next letter while the last one was being typed. This overlapping of operations was only possible through the interaction of their microworlds.

Both Anna and Susan developed viable microworlds which were enhanced by the dynamics of the process network. Because of an expansion of ideas, an extended perspective, efficiency and simplified confirmation of processes, the process network created richer microworlds for each of the girls.

c) process network - student/student/researcher

What kind of network evolved when this collaborative network involved the researcher?

When the researcher presented them with a sketch (figure 2) which she thought involved making a design and rotating the design, their first solution was to make a variable procedure for a square and increase it in size.

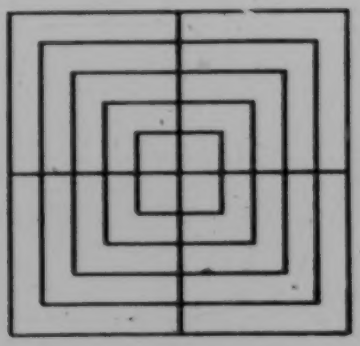


Figure 2: Sketch

The following conversation ensued:

R "That's interesting because I never thought of it that way. I thought of a way that was making smaller or bigger squares but differently."

A "Another way you could do it, you could make a procedure for this one (one quarter of the design) and then repeat it over."

R "I guess that's what I was thinking about. How could you do it that way?"

A "Ok, you would make a square about, how big would that be (pointing)?"

R "Just take a guess - about 5".

A "Ok, and like you make this one and then you would end right there and then you would go forward and you would do that, and then you make a whole procedure out of it."

(drawing on paper)

R "If this one is square 5, then what is this one?"

S "6"

R "So then you just do - How are you going to put that in your procedure?"

A "You start there and then go like that and just keep making it bigger and just keep repeating it."

R " Right, so you would have to put square 5, square 6"

S "Actually you would have to turn the thing because if you just did it like that the square would be down here."

A "So you would have to turn it"

R "So what am I going to do, like say, 5,6,7,8,? And then I'm going to turn it? The turtle is going to be back here again."

S "And then he would have to be facing this way?" (she points)

A "So right 180 or left 180?"

R "You turn and he's up this way?"

A "No, he is just facing down, right 180 or left 180?"

R "Why down?"

S "It's like a flip."

R "So then he went that way and then like this. So if I turn him right down he is going this way then he is going to go..."

A "Maybe on this one you would have to change direction, because instead of going the left way, or whatever, he is now going to the right."

R "Yes, that's one way to do it."

S "It's sort of like the setpause."

R "You might have to do that. I think there is an easier way. Facing this way, I want him to go like this. He just needs to go that much (shows 90 degrees)."

A "Oh yeah he does."

During this conversation all three participants were involved in the conversation, making suggestions, demonstrating their thoughts, and explaining things to the others. Although the researcher was the instigator of the whole situation, the conversation was not dominated by her suggestions. Generally, the conference involved a three way discussion with each person's views being valued. The evolving learning environment was a rich collaborative one with the researcher being integrated into the group. The collaborative nature of Anna and Susan's network was maintained by accepting the researcher as part of the group.

Susan and Anna took the opportunity afforded by this collaborative atmosphere to raise ideas that they wanted

to discuss. On Feb. 21, Susan decided that the very next thing they needed to do was figure out how to make an R. While on Feb. 27, she came to the conference wanting a solution to a problem they were having with their design and was not prepared to wait for the videotape to play or the researcher to introduce a concern: she was determined to solve that problem. The process network that was developing emphasized noncritical discussion and a pooling of ideas for solving the problems. The three ~~group~~ members' microworlds intertwined to work with Logo on several occasions such as on March 9, when the conversation was concerned with the erratic colouring of rectangles in a grid.

R "You painted the rectangle the one colour - the colour you already had. So then you went forward 10 to set the paint colour to the other colour, painted left. Why did you have to set the paint colour at the end if you didn't have to do it at the beginning?"

A "Because it was already the colour."

R "If it is already, why did you have to do it?"

A "No like at the beginning"

S "She's talking about like at the start you already had it that way - purple and if we didn't have this (the

setpencolour command) we would still, when you finish right here."

A "No it wouldn't Susan because look at it. We had it purple at the very beginning, then we painted it (this isn't the procedure we already have it) so we painted and then we went forward 10 and set the paintcolour 5 so it would be blue and then we have to set it back to purple because the purple we started with isn't in the procedure."

S "Ok, I thought it was in the procedure - right there at the start."

R "it doesn't really matter where you do it. I just wondered why it had been in that place."

While attempting to understand the process of colouring the rectangles, everyone's contributions are treated respectfully.

On another occasion, when Susan understood that their design could not be rotated radially because a setheading command had been used, a fact that had eluded the others, she explained the situation:

R "So that's what happens if you overlap them and they are going up. What about if you turn it somehow so that

you're always turning it this way (radially). What would happen?"

S "Can't do that."

R "Now where's the turtle?"

S "It's right there. Now we should go to the middle and just turn it or something."

R "Either that or to where it starts."

S "Beautiful. It doesn't work."

R "It's getting a line going...."

S "I knew it wouldn't work because the turtle isn't facing straight."

R "It looks like the angle isn't just right."

S "You know how we have setheading 90. Ok, watch it"

A "We'll take out the setheading."

R ".....Let's look at it and we'll try to see just what she means."

(they try a few experimentations)

R "Now I know what Susan's talking about - where you turn, in the middle, it's always going to say setheading

90 and do that no matter where you started. So the way you made the procedure you can't turn it around. That's right."

S "That's just the way it is."

No special consideration was provided for the researchers' slow wittedness: she was simply another person to be convinced.

After one proposal by the researcher, Susan mused "that might work" while Anna commented "that's true - makes sense". The researcher's suggestions were always evaluated and never attempted simply because they came from an adult. Once again no special priveleges, only equality.

Another indication that the researcher was accepted as an integral part of the working group, was the way her ideas or actions were ignored if they were not in tune with the topic receiving attention. This was particularly clear when Susan and Anna were trying to work on a solution to their problem with a procedure called "fcross" while the researcher attempted to use the videoplayback and ask general questions. The girls were intent on working out their problem, which they proceded to do even though the researcher attempted to refer to the tape and delay attempts at examining this problem. The researcher's remarks were ignored until she made a comment regarding

the problem, whereupon the three members of the group began to struggle with the challenge together.

The process network which evolved was dependent on the free flow of ideas among the participants. As mentioned above the participants appeared to be sharing a search for 'understanding which was nonjudemental and egalitarian. Such a participatory experience was indicated by an examination of the researcher's remarks made during the conferences. Although the greatest number of comments were of a probing nature (135), this was closely followed by suggestions (97), reaffirmations (66), and explanations (57) (see Appendix D). The high use of comments confirming others' ideas and bringing forth ideas in an unassuming way, as well as the employment of phrases showing that a search is underway (22), indicated that a three way exchange was in effect.

Did this dialogue generate ideas which were introduced in Anna and Susan's computer work? During a conference the directions for making an R, involving a diagonal line, were pursued. The idea of finding the length of the diagonal by multiplying the length of the side by 1.41 was experimented with and utilized the following day. A week later Anna was ready to use this information again in making a design. The reseacher explained the inapplicability of the method in this case, whereupon Anna

turned to the other method which had been reflected upon - guess and check. Several days after discussing and trying several radial tessellations, Anna suggested that they try to make a design and to move it radially. Many concepts were thrashed about in the conferences and subsequently applied in the computer work.

[Remark: There were 3 times when there was no follow-up of ideas that I considered to be big ideas. In 2 of these cases the assignment was changed following these conferences thus limiting the usefulness of these ideas in the immediate time frame. In the other situation I feel that I introduced a concept that they had no need for at the time and that I introduced too much information at once.]

During the course of the conferences, the suggestions that the girls had for future extensions of their projects blossomed. During the first conference they required several probings to produce an idea which was only a slight variation of their original attempt but as time progressed they had more and more creative and original ideas. On Feb. 27, when asked "What are you going to do after this? Do you have any ideas?", they mentioned making a pattern by putting together a lot of the shapes or making a circle of shapes attached at the corners or attaching the shapes in the form of a throwing star or

various colours. Many of the notions considered in the conferences were incorporated into their thinking.

Was a viable and useful process network developed among the researcher and the students? Susan had a perspective on this which may be helpful. She remarked to the researcher that "you helped us fix it " and that the conference allowed a time when "we can figure it out together".

Case Four: Mike and Alan

(conferenced)

At first, Mike, a very quiet grade 6 student, was an observer but this changed dramatically to the point where Alan said "I can't think of anything but Mike is pretty good at it". Mike began by becoming more assertive. "I know how to do that (make a procedure). Here I'll show you." Several days after he became the typist, he began to use his own ideas and demonstrate characteristics of a steady worker. He became very involved with the projects and ignored distractions. Even when Alan became disinterested in Logo and "it was like working alone", Mike kept working steadily. In the conference, he rarely volunteered information until the later part of the research period at which time he began to contribute freely to the conversation. By Feb. 9 he was conversing with Alan at the computer and giving some instructions. Mike was not a risk taker: he wanted to feel that success was imminent. Indications of his guarded confidence were that suggestions were not offered until after a initial period of observation; at first he typed whatever Alan wanted; and after he began to use his ideas, he stuck to methods that had proven fruitful or that he had been told he used well. Mike preferred the castle project because he liked to be creative and do his own thing. His favourite school activity was creating stories.

"The computer should be intelligent and then I don't have to think" exclaimed Alan, who contrasts with his partner, Mike. He was lazy and didn't like to think very hard and would sit back and let others do things for him. He was willing to have the teacher, Mike or anyone else make procedures for him and not even search for an explanation. By Feb. 9, after several explanations and experimentations, he still needed to ask Mike how to save a procedure. It seemed that he did not want to exert the energy to understand Logo. When questioned, commands such as REPEAT or concepts such as procedure would be rememebered and explained but this knowledge was not incorporated into his work. He did not pay enough attention to details: a fact that caused him much frustration, such as in the ensuing conversation:

A "In squares, you could either put the squares on top or the sides"

R "Would it be the same command if you had it up here or down here."

A "Yeah"

R "It's the same command except...?"

A "If you are going to do that it's the same."

M "But what is different about that. If I have one up here and one down here? Alan is saying that they are both exactly the same command and he can't understand why it would end up in a different place."

A "So here left like that..."

R "So you had to tell it to go left there"

M "You have to tell it <u>exactly</u> "

R "Exactly what?"

M "To turn around this way instead"

R "Ok, and that is one of the differences is that you have to tell it exactly and that is one of the things that we sometimes forget to do."

He would be pleased if a computer could read his mind: he wanted to put down an approximation of his plan and have the computer figure out the details. Throughout the research period, his conviction that the computer was changing the commands was maintained. The personification of the computer in his statements of frustration, "how dare it do that" or "the computer gets a kick out of that", did not change with experience, indicating the strength of his belief.

Alan spent an inordinate amount of time talking about unrelated topics which distracted him from the projects. He thought it would be better for him to work alone to decrease the amount he talks and force him to do things himself. He stated "Mike made all the decisions that's why I learn more alone". Indeed, he appeared to need to be in charge of the project or he would retreat. In the beginning he was the main instigator but as Mike's involvement increased Alan's contribution dwindled until it was nonexistent.

Alan wanted to be allowed to be creative in his projects and produce something different from other people. He didn't like doing the initials because it was too difficult getting the angles and "it's tough making letters: pictures are better ".

The circumstances of working in pairs had a substantial effect on Alan and Mike's working arrangement. At first, Alan typed and initiated the moves while Mike was an observer answering a minimum of questions. Because Mike needed something to do and was a faster typist, Mike took over the keyboard. Gradually, Mike started contributing ideas and Alan withdrew from participation.

Reflection

Examination of the problem itself was the primary target of reflection in solving Logo problems. Although they did some talking, most of it was in the form of a statement rather than a discussion and questions asked of the partner often were not answered.

Generally, the methods used in reflecting focussed on the mechanics of the problem and not on the generation of new directions. Guess - check - adjust was used almost exclusively (see fig. 6 pg. 111). An examination of the methods used on separate days show that by the end of the research period Alan and Mike were using more variety in their methods and were doing more talking but guess - check - adjust retained its top position.

Writing, drawing or moves were rarely employed as methods. Since commands were not written down for future use, this group sometimes used textscreen to see the commands. On Feb. 20 previous work was referred to several times in order to figure out the angles to be used in a triangle.

The methods Mike would use to decide on his next step were talking, going to something different "until I could think of an answer" or "think it out". Similarily, Alan

would think or talk since "two minds are better than one" and "other people look at it differently".

Context

a) microworld

Alan's micrworld seemed to be confined by a limited understanding of his potential in the Logo world. Increasingly throughout the experience, Alan seemed to be overwhelmed by a lack of control over the computer's actions and he withdrew. There was no indication that he felt he was working with Logo to find a solution, rather he was fighting a computer that changed his commands. Alan's 19 signs of frustration (see Appendix E) were all aimed at the computer and its habit of doing something different. He grumbled "how dare it do that"; "it's probably going to think it has 4 sides" (instead of the 3 he indicated); and "it takes different ways than you told it". If he was having difficulty understanding something, he didn't search for an explanation but gave up instead: as if understanding was an impossibility. After the teacher suggested that he try a procedure to discover the method, he tried something but then quit without pursuing it further. It would seem that he felt even more powerless when he was not at the keyboard and he withdrew from participation. His withdrawal was most acute

during the initials project (assignment #4 - see Appendix A). He did renew his relationship with Logo, hesitantly, during the division of the rectangle and the castle assignments. On March 8, he commented "we got a lot of things accomplished today" and he began to make suggestions for the next day. At this time their actions were successful and Alan contributed to their input. His development had its ups and downs dependent upon wary participation during smooth times and retreat during the rocky times. Alan did not seem to develop a viable microworld.

Mike's microworld evolved in a steady, quiet fashion. He had a solid relationship with Logo, recognizing his position in the Logo world. He realized that he had to work with Logo: it was a two way street. His contribution to making the dots in the initials was to give the directions and Logo would make them.

M "You have to put dots too."

A "There are no dots on here."

M "You have to make them."

"You need a rectangle for this.....make it size.....how big is the letter?"

On Jan. 27, when the commands for ISLE seemed to be lost he stated "I guess we didn't make a procedure" and was ready to begin again, reinforcing his steady attitude. If the result was unexpected he thought he had done something wrong and it could be rectified.

His interactive role with Logo developed from a nonparticipating observer, to a tentative participant when he first took over the keyboard, to a participant who kept on trying and took advantage of any suggestions. Interaction was direct with ideas being attempted immediately on the computer. He rarely made a written or drawn plan. He made extensive use of the guess - check - adjust method of solving problems once it was pointed out that he used this method well. He purposely used this method in managing Logo problems, thus developing a stable relationship with the Logo world.

b) process network - student/student

The network produced by the coupling of Mike's stable world with Alan's tottery one was not harmonious. The network was not based on collaboration or cooperation: first, one member was dominant in that "Alan had all the ideas and I didn't have anything to do", and then it switched to "Mike made all the decisions, that's why I

learn more alone". At times it did seem that they were working alone. They were not able to cooperate. Their worlds pushed against each other but did not overlap sufficiently to produce a working network. Alan's withdrawal reached its peak during the initials project. At this time he often did not answer questions, and sat despondently, or talked to other students about disconnected topics. Later, on the division of a rectangle, contributions were given by both Alan and Mike. This cooperation existed during smooth times but when a snag was reached, Alan fumed "this is so stupid!" while Mike commented "now I've gone too far" as he continued to work. At this point their different outlooks towards Logo led to a breakdown in communication: Alan thought the computer was playing tricks while Mike was searching for mistakes. As a result Mike worked harder and Alan withdrew from interaction. For short periods of time their attempts complimented each other but most of the time they were alone.

Both Alan and Mike expressed a desire to work with another person rather than alone, claiming that "two heads were better than one" and yet Mike, who felt that "working with Alan is like working alone", made the best of it while Alan rejected participation in practice. This discordant network was not rewarding for either participant.

It was ironic that although they desired communication, it eluded them. The data indicates that they were talking, but talking is not necessarily communication, a fact, made clear by their experience. Their words were not used to discuss ideas or future schemes but were demands for assistance from the person in control. On one occasion, Mike asked Alan for the numbers to use while another time Mike wanted to know the height of the letter, to which Alan mumbled "how am I to know?". Another time Mike's query about which colour to use was answered with a comment about the placement of the turtle. Their words did not generate understanding but conflict. The evolution of a process network was inhibited by this lack of communication and cooperation.

c) process network - student/student/researcher

The network arising out of the inclusion of the researcher in their interaction developed within two situations: one in the computer time which is on videotape, and the other in the conference time which is recorded on audiotape.

During the videotape sessions the researcher attempted to limit the interaction to times when she was asked or to times when the students were at an impasse. The researcher initiated the contacts with Mike and Alan. Most

of the researcher's comments were of a probing nature (16) with (8) explanations, (3) telling statements, (2) searches, (1) reconfirming statement, and (1) suggestion (see Appendix D). Of the 18 situatons in which comments were made, there was follow through on 17 of these. Since probing remarks were usually employed to encourage the students to reexamine a situation, a high degree of probing remarks coupled with explanations, suggested the researcher's role was one of developing an understanding of concepts. An opportunity was also present for the modelling of strategies such as on Feb. 13, when the researcher modelled the use of line by line editing while searching for the source of a problem in making a square.

The process network which developed during the conference time with this group was quite structured and was dominated by researcher initiated topics. A majority of the remarks made by the researcher were of a probing nature intended to explore areas of difficulty or where increased understanding was deemed desirable. These areas were identified through observation of the students and the videotape. Sometimes the students raised topics needing clarification but Alan and Mike relied on the researcher to initiate most discussions.

Conferencing allowed for the development of understanding of procedural ideas and the strengthening of ideas. Discussions to expand understanding dealt with procedures, the repeat command, using a repeat within a repeat command, variables, and the relationship of a person with Logo. The three way discussion allowed for the opportunity for selected ideas and strategies to be reinforced. Innovative methods or ones that were working well could be accented. Mike's employment of the guess - check - adjust strategy was strengthened by the use of positive reinforcement during a conference. Not only did he continue to use this successful tactic but he was aware that he was using an acceptable and winning strategy.

The conferencing structure that evolved in this group relied on probing for discovery, providing an explanation if necessary, and guided practice. A categorization of the researcher's remarks reinforced the idea that this structure was followed with this group. There were 227 probing remarks, 60 explanations and 60 suggestions while there were only 6 comments that were telling in nature (see Appendix D). The researcher spent the majority of her time in building concepts. Most of the work and organization in this conference group was done by the researcher.

On Feb. 15 they were having difficulty understanding what the variable did. During the conference this concept was explained, developed and then practised with a square and triangle. Success was achieved in using a variable in a triangle procedure at the following computer session. Although the process network was not collaborative in nature, it was a useful milieu for developing concepts. The traditional organization of the conference with the adult in charge may have limited the topics explored but since numereous concepts found their way to future computer work, the conference topics must have been relevant and of assistance. For example, having worked through examples of combining a repeat command with a move procedure with the researcher, this manoever was successfully utilized in their work. Following a discussion concerning the possibilities to change the positioning on the screen, they used one method the next day.

The traditional format allowed the researcher many opportunities to model strategies of reflection, such as following the directions in line by line editing, on the screen or on paper.

Although the process network did assist the students in developing understanding and aquiring new strategies, it was confined by its narrow structure and would not develop the breadth created by a more open organization.

CHAPTER FIVE

FINDINGS OF THE STUDY

The focus of this study was on examining reflection within Logo, an interactive system. The data were examined for types and methods of reflection employed by students. In addition, the contexts within which Logo operated were examined for the presence of reflection and its contribution to contextual development. Examination of the reflective methods will be followed by a discussion of factors arising out of the contextual networks.

Methods of Reflection

In this study, several types of student behaviour were taken as methods of reflection. Each type is briefly described below.

1. **talk:** In talking to other people the participant is often looking for additional information or an alternate perspective on a situation which is seen as perplexing. One contemplates and evaluates the usefulness of each idea often in a critical way. Similarly, in talking through the instructions, reflection is taking place.

2. **write**: In writing down instructions or notions, one is often thinking about the effect of these ideas, making decisions for or against their inclusion.

3. **draw**: During the act of drawing or sketching, one compares the diagram with the picture in one's mind, evaluating and revising all the time. One might also create ways to translate this picture into a graphic display.

4. **moves**: In moving, the participant is actively seeking additional information, often in respect to perspective, required to complete a thought.

5. **textscreen**: By wanting to visualize more information than is presently available, one is showing a preparedness to mull over this information.

6. **previous work**: Referring to other projects indicates that a comparison has or will be made between the procedures. Information gleaned from comparing can be used in revising the present project.

7. **edit**: Editing involves a close examination of a procedure command by command. Constant comparison is conducted.

8. **GCA**: Guess - check - adjust is used to refine a procedure when a strategy for solution has been decided

upon. It often requires comparison and reorientation in using the information to refine the guesses.

9. **GCAexp**: Experimentation is the method of reflection when a theory is being devised. In this process comparisons are made and ideas contemplated until a concept is formed, ready to be tried.

10. **long wait**: What transpires when someone is thinking? It could be many things even a clearing away of the jumble collected during earlier attempts. It may be an attempt at seeing from a different perspective. The indication that something has happened during these periods is the resultant action taken to solve the problem at the end of the time.

11. **go to something else**: How can not dealing with the problem be considered reflecting on the problem? To remove the problem from the immediacy of one's mind, to go about some other business and to return gives one a new view of the situation. In the new context, a different strategy may result. Hoff (1983) in THE TAO OF POOH presents a similar view:

> An Empty sort of mind is valuable for finding pearls and tails and things because it can see what is in front of it. An Overstuffed mind is unable to. While the clear mind listens to a bird singing, the Stuffed - Full - of - Knowledge - and - Cleaverness mind wonders what kind of bird is singing. The more Stuffed Up it is, the less it can hear through its own eyes. Knowledge and Cleaverness tend

to concern themselves with the wrong sorts of things, and a mind confused by Knowledge, Cleaverness, and Abstract Ideas tends to go chasing off after things that don't matter, or that don't even exist, instead of appreciating, and making use of what is right in front of it (pg. 146-147).

Perhaps the value of "going to something else" is that it clears one's mind of the clutter collected during previous attempts, allowing one to return with a fresher new perspective.

Which methods of reflection were used?

In order to provide a concise, visual description of the results of analysis, graphs of each group's use of reflective methods are provided in figures 3 - 6.

Figure 3: Reflective Methods - Jean and Karen

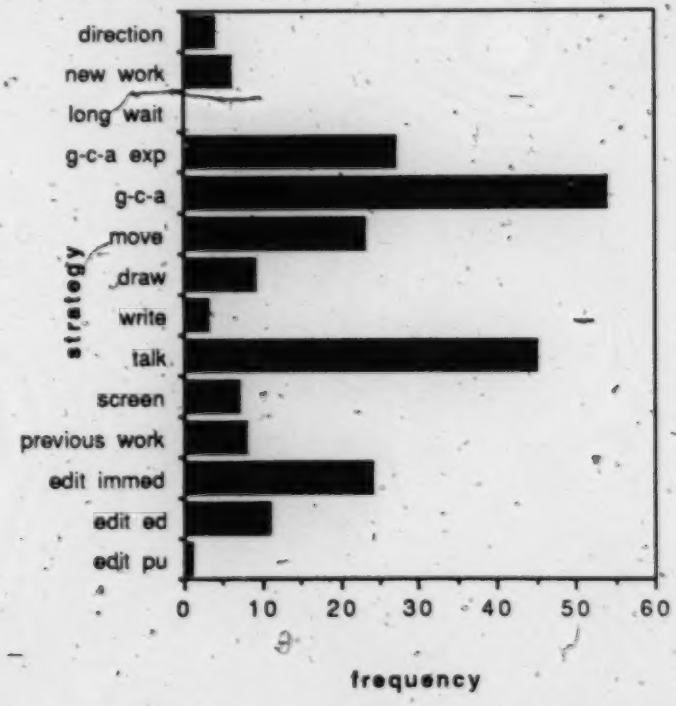


Figure 4: Reflective Methods - Ross and Simon

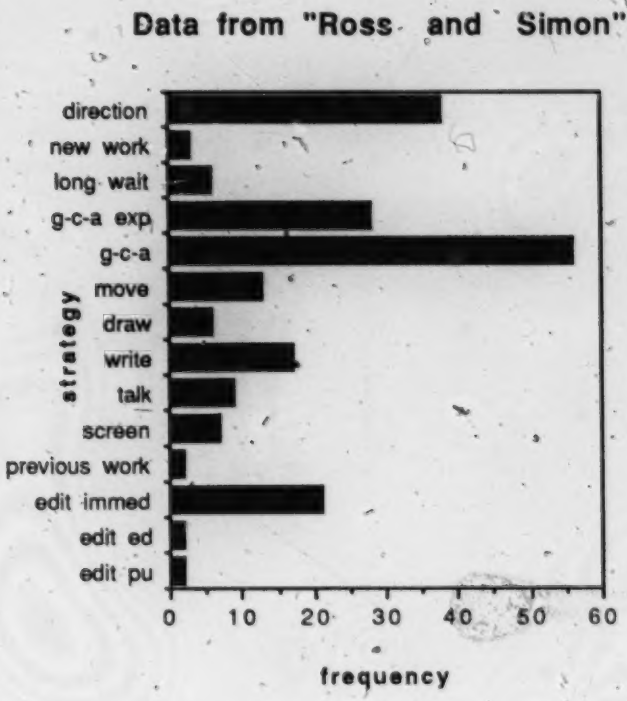


Figure 5: Reflective Methods - Anna and Susan

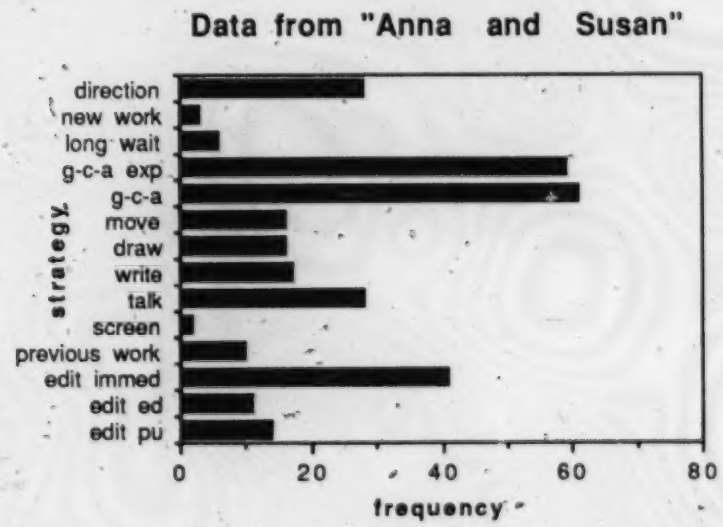
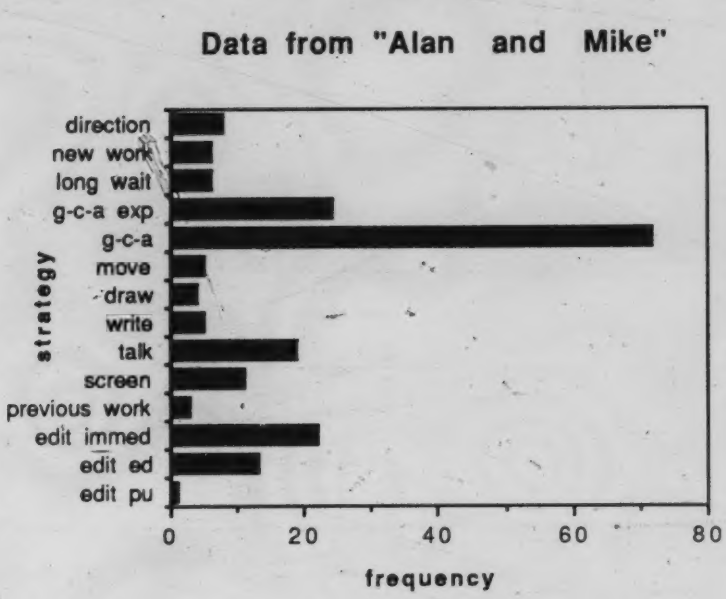


Figure 6: Reflective Methods - Alan and Mike



Since almost every method was used by each group, a further comparison of the most commonly used methods by each group was prepared (figures 7 - 10).

Figure 7: Most Common Reflective Methods - Jean and Karen

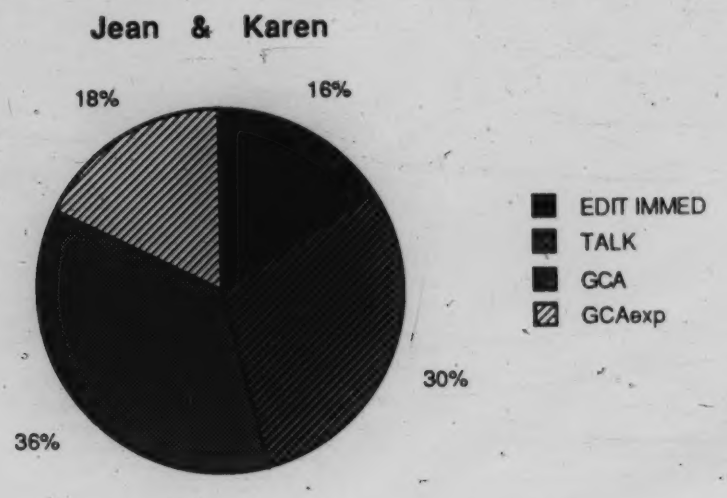


Figure 8: Most Common Reflective Methods - Ross and Simon

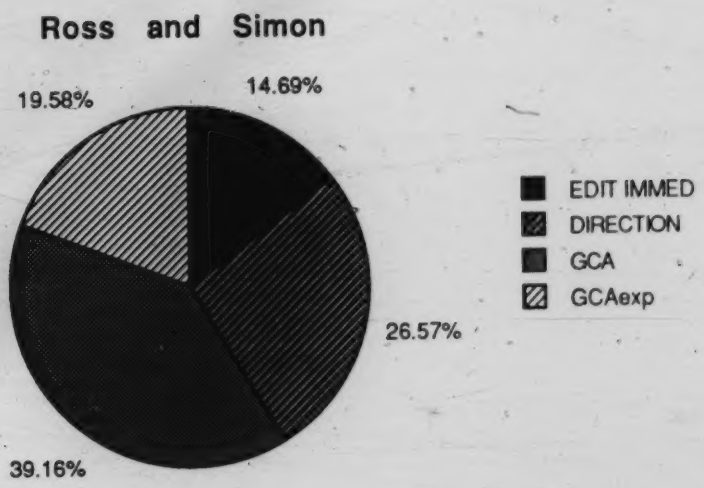


Figure 9: Most Common Reflective Methods - Anna and Susan

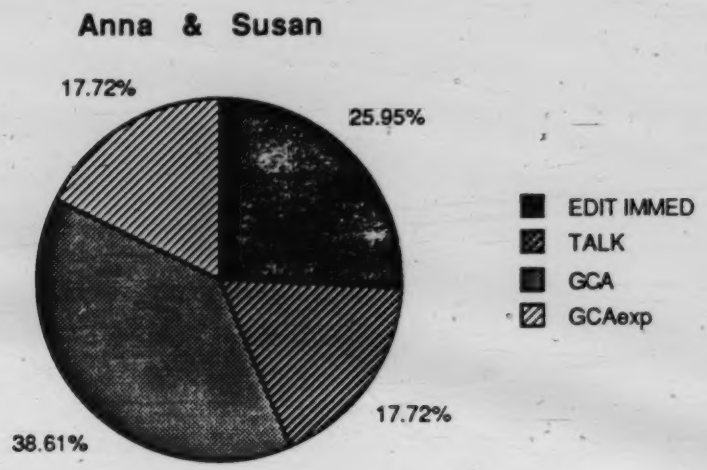
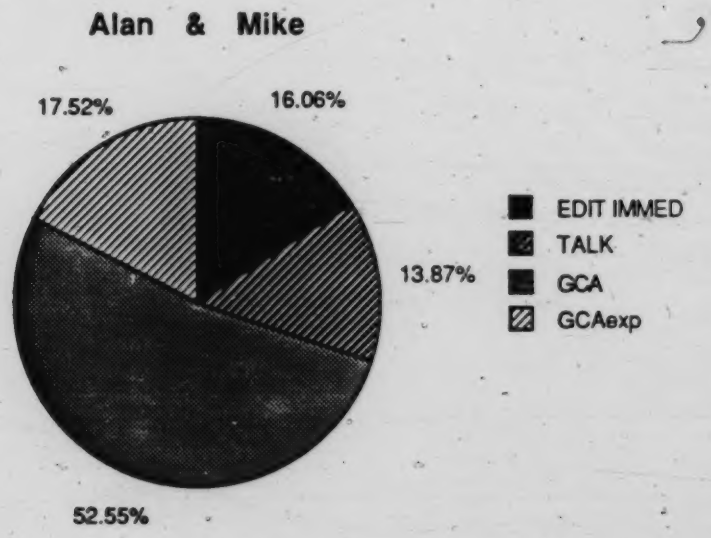


Figure 10: Most Common Reflective Methods - Alan and Mike



1. **Guess - Check - Adjust**

The most frequently used method by all groups was guess - check - adjust (GCA). All groups also had high usage of experimentation (GCAexp) and line by line editing in the immediate mode (E). In three of the four groups talking was also among the most frequently used methods.

Since guess - check - adjust was by far the most commonly used strategy, it may be that enhancement of this method of solution could be possible through the use of Logo. Why would this particular method of problem solving be so prevalent in the solution of Logo problems? Does Logo structure promote Simon's method of "fooling around and trying to get close"? Logo structure may actually stress a "closing in on the solution". In Logo usage, one is encouraged to turn one's ideas into procedures and to modify the procedures through editing. This process of devising a plan and then modifying promotes the use of a guess which is tried out and then adjusted in accordance to the information supplied by the trial. In addition, the fact, that Logo commands lead to an instant graphic display which can be adjusted and reflected upon without delay, generates the use of this method. The procedural structure of Logo coupled with the graphic display invites the use of guess - check - adjust.

Similarily, because of the immediate graphic display, experimenting with ideas and adjusting these ideas until a pattern (theory) is devised, receives encouragement from the structure of Logo. A pattern of solution commonly used by these students was experimentation with evaluation until a concept was evolving, whereupon they would switch to guess - check - adjust for fine tuning.

The functioning of the Logo language also invites line by line editing through the ability to try a procedure one command at a time with each command being displayed as it is given. This allows a procedure to be reflected upon and even compared with a diagram or written instructions. Line by line editing in the immediate mode was conducted either at the idea development stage when various thoughts were brewing or at a later time when inconsistencies needed to be reviewed.

2. **Talk**

Almost all of the students deemed discussing and talking to others as critical in developing ideas. For three of the four groups talking was a frequent reflective technique. Words were used to express hunches, to point out misconceptions, to explore possibilities, to ask questions, to give suggestions, and to express feelings.

Talking was significant in extending the consideration of thoughts.

Talking as a reflective strategy appeared to be extremely important in nurturing Logo networks. An examination of Logo networks revealed limited microworld development for Ross and Simon, demonstrated by slow progression in their Logo work. Ross and Simon, with the fewest instances of talking as reflection, had restricted microworld growth. Their reticence hampered extension of their experience through the medium used by the most successful groups - words. By not seeking assistance and discussing difficulties, they allowed their confusions to fester, becoming hindrances.

In contrast to Ross and Simon, Susan and Anna, as well as, Jean and Karen used words extensively. Being able to express their own ideas and expectations, prevented interpersonal relationships from interfering with their Logo work. They discussed inconsistencies and pooled resources which led to a richer, progressive experience. Using words to contemplate a problem or extend a concept or reflect upon future plans was a successful strategy for these groups. In these cases Alan was right in saying that "two heads are better than one".

Anna and Susan emphasized, that there was an important learning difference between a situation where someone explained a concept through showing while telling, rather than telling and doing or just telling; "(talking) helps me but it is even better if they show you and are telling you at the same time". Anna and Susan were strong believers in experiential learning: one had to do it oneself to learn. Someone doing a task for you did not promote learning; telling had a better chance; but working through the concept with you was the best learning experience. This difference may have contributed to the lack of progress shown by Alan and Mike, since their talk did not consist of explanations but of demands for information. When this information was given, it was used but not explained by the demander, leaving one partner "in the dark". This lack of communication increased the gap of understanding between the partners, resulting in Alan's retreat from interaction. A circular cycle evolved which made it difficult to build upon their ideas and concepts. Noise not communication was heard: talk became a search for numbers to be plugged in rather than the generation of ideas for pondering. This emphasis on numbers rather than meaning, maintained interaction at the existing level. Mike asked for the lengths of lines or the commands for colours rather than discussing whether a line should be made or which colour would be appropriate.

The strident character of Alan and Mike's interaction; was an impediment to their progress.

Verbal interaction was also critical to Jean and Karen, experimenting with a procedure for a design called sta (assignment #5 - see Appendix A). Reflecting upon the effects of making increasingly larger designs, words assisted in shaping their ideas.

J "let's try an angle rt--"

sta 6.5 sta 7

J "now put rt"

sta 7.5 sta 8

J "we'll go up to a number and down again like to 9 and then down again"

fs sta 8.5 sta 9

J "oh this is cool" (wraparound effect)

Words assisted the girls in pondering the importance of the wraparound effect: they discussed a concept, made suggestions, and made decisions. They used communication as a medium of contemplation, exploring possibilities. Communication was a two way exploration not a request for isolated information. Anna and Susan, and Jean and Karen

developed a working relationship which enhanced their interaction and thereby their relationship with Logo. Through verbal discourse they shared ideas, suggested future plans, assisted each other with problems, or discussed their feelings about Logo or the working situation.

3. Other Methods

An examination of figs. 3 - 6 indicated that Anna and Susan employed the greatest variety of reflective techniques followed by Jean and Karen, Ross and Simon, and Mike and Alan. It seemed that the group which had developed the clearest understanding of Logo worked with the greatest variety of strategies.

Outside of the top four strategies, a wide variation of techniques were used. Ross and Simon had a high usage of "direction" while the only other group to use this method to any extent was Anna and Susan. Jean and Karen did not try a "long wait". The only group to take advantage of "edit pu", to any extent was Anna and Susan. Writing and/or drawing were only significant methods to Anna and Susan, and Ross and Simon.

It would appear that the students' most widely used reflective strategies were guess - check - adjust, experimentation (GCAexp), edit and talking but that the

adoption of a wide variety of methods would be advantageous.

CONTEXT

a) Describing microworlds

Individuality was the principal component of a microworld. Each microworld was an entity unto itself, evolving at various rates. The evolution ranged from smooth and systematic, to impulsive and sporadic, to rough and infrequent. Jean, Susan, Anna, Mike and Simon all built microworlds that might be described as systematic and organized. Karen had an "impulsive" relationship with Logo while Alan and Ross maintained "strident" microworlds. The type of microworld that developed depended on each individual but was also influenced by many factors operating within the Logo classroom. These factors are discussed below.

Pairing

The most obvious influence was that of pairing. Having two students at one computer determined the working arrangements in that one student would be at the computer with the other as an observer. The possibility of sharing roles through rotation never occurred: without intervention

from the teacher or researcher set roles were taken by each pair. The decision concerning roles was made jointly, taking into consideration the strengths already possessed by each person. This spontaneous division of roles destined some individuals to a more distant "theoretical" relationship with Logo.

Susan, working with Anna, and Jean, working with Karen, were able to turn the pairing situation into a cooperative learning situation. They were able to cooperate with their partners and their ideas were heard and utilized. Being determined, Jean never let her suggestions go unheard. She made certain that she had as close a relationship with Logo as would be possible in the circumstances. Although, Karen and Jean didn't change roles while they were being taped, Jean did work directly with Logo on other days by using a separate computer. By changing the physical arrangement, Jean exrerienced both roles. She could try her own thoughts at the computer, bringing any acquired understanding to the group. Susan's variation of pairing led to the evolution of a viable microworld. Susan, the planner, was connected to Logo through paper. She planned the moves that were made on the screen but she also followed the commands line by line on paper to confirm the moves. By working through the procedures, in a manner similar to online editing, Susan developed a growing

microworld. She interacted with Logo in a manner similar to someone at the keyboard but in a more abstract fashion.

On the other hand, Alan, working with Mike, and Simon, working with Ross, were unable to create viable microworlds in their situation. Although Simon's relationship with Logo was very regular, organized as it was through planning and recordings on paper, he did not build an evolving microworld of new concepts. Since he did not usually have the opportunity of utilizing his ideas without an argument, he was often thwarted in his attempt to encompass new concepts, leaving Simon's microworld stable but undeveloped. Alan's microworld was an area of contradiction. He did not comprehend the functioning of Logo, or control within Logo and his actions produced clashes which inhibited growth.

In addition, the microworld formed by the person designated to remain at the keyboard may have been influenced by the presence of a partner. The keyboard operator might have done more planning, especially on paper if the planner role had not been fulfilled by their partner. In the present study Anna and Karen were the only participants at keyboards to do any planning and these plans were normally completed beforehand: Karen began planning when she was at a separate computer while Anna

planned out of computer class. Karen began her Logo experiences as a nonplanner but after working at her own computer for awhile she began to put some plans on paper.

While the pairing of students affected the Logo microworld by limiting the possibilities for interaction, the pairing also increased the opportunities for enriched development. Having a constant companion for consultation could expand the evolving microworld through the sharing and extension of thoughts. Having a regular partner was an asset to Anna and Susan. Because of their collaborative attitude, they were able to derive more understanding of the Logo world together than would have been possible alone. In the case of making procedures for the letter assignment, they shared the work: Susan planning future procedures while Anna typed in the previous one. In this way they became very efficient and were able to explore more territory than would have been possible alone. Having a partner made it possible for them to elicit more ideas than individually.

In their attempt to find the correct length of line in their design (assignment #5 - see Appendix A), each partner contributed information or strategies which may not have arisen so easily without the repartee between the

partners: each suggestion or action arose as a response to the partner. As each participant said "you get more ideas from your partner".

As partners Jean and Karen were mutually supportive. They were able to discuss ideas, and sort out theories, even when they worked at separate computers, largely because they had been provided with a co-reflector. Jean was able to assist Karen in times of frustration and through modelling strategies, strengthen her relationship with Logo. In a smooth operating partnership, being paired enriched each microworld. On the other hand, pairing often created friction which decreased the effective development of microworlds.

Control Within Logo

By working on Logo projects, all of the students in various ways were developing microworlds and thereby increasing their control within Logo. This control was generated at a variety of rates with Jean, Susan, Anna, Mike, and Simon having smoothly evolving microworlds. After a shaky start Jean's interaction had settled into an orderly structure in which she employed a variety of methods of reflection to sort out her thoughts, believing that she controlled the operation of Logo. Utilizing a variety of reflective methods, Susan and Jean had developed

a very logical, regular approach to Logo problems, and not surprisingly expected Logo to react in a reliable, systematic manner. Even though Mike used quite a limited repertoire of methods of reflection, he was consistent in his approach, believing that he controlled Logo and enjoying a steady development in his understanding. Simon's microworld was very organized but his ideas had not been extended, leaving him with a very narrow scope of competence. The evolving microworlds of the above students had their own character but through trusting the reliability of Logo, were growing.

In contrast, Ross, Alan, and Karen had microworlds developing on "rocky terrain". Karen's interactions with Logo were impulsive and experimental with little planning taking place. She would reach a frustration point easily, transfering her dissatisfaction to the computer. She believed the computer did it's own thing and she did not accept responsibility for its functioning. Ross's interaction with Logo was experimental and hurried. He reacted quickly without thinking, his constant checking of procedures indicating a lack of trust in Logo to react in a reliable fashion. Alan's interaction with Logo was sporadic. His conviction that the computer changed his commands remained strong throughout his experience. His inability to

overcome this powerless feeling hindered the expansion of his understanding.

It was this notion of Logo controlling the action that seemed to restrict the interaction between Alan or Ross or Karen and Logo. When confronted with this feeling of powerlessness, Karen became angry and unable to procede, Alan withdrew, and Ross deleted the commands and searched for other procedures to confirm that the computer had not changed them. These students were unable to appreciate that Logo could be working for them. Their actions indicated an acceptance that a struggle existed between themselves and the computer, not allowing much opportunity for growth. The participants, who were creating a smooth evolving microworld, had a firm understanding of their position in the Logo world. They worked in concert with Logo and controlled the action; if something was amiss it could be rectified. It would appear that possessing a firm conviction of one's control within Logo and a trust in its functions is necessary for the evolution of a stimulating microworld.

Amount of reflection

All of the participants engaged in reflection while working on Logo problems. Alan and Ross had the lowest use of reflection: Alan as a result of his withdrawal

from participation and Ross because of his speed in rejecting proposals. Alan's withdrawal did not allow for interaction with Logo problems, therefore his microworld was not expanding. Ross did not permit any time for reflection. His staccato style produced quite erratic, uneven development. The other participants used the information derived from reflection to build upon their Logo solution, thereby stimulating their microworld development. In contrast, Alan and Ross by avoiding reflection decreased their opportunities for creating microworld experiences. It would appear that reflection reinforces microworld development.

Methods of reflection

A microworld, created by the interaction of the participant with Logo, is affected by all of the methods of reflection identified in this study. The information derived from reflecting, whether it be talking, experimenting, drawing or a long wait, could be used to revamp a procedure, thus affecting one's interaction with Logo.

Approach

Which approach to Logo created the "best" microworld? The arguments over what consitutes "best" could be endless. "Best" for whom, and by whom, how much and of what? For

the sake of this discussion, a "better" microworld might be taken as one that was based on an awareness of one's control within Logo and one in which most Logo problems were solved. Using this criteria, Jean, Susan, and Anna had good microworld development; Simon and Mike had satisfactory development; Karen was borderline; while Alan and Ross had poor microworlds. The first five students mentioned all had a systematic, logical or orderly approach to solving Logo problems. They reflected upon their problems, using either a wide variety of methods (Jean, Susan and Anna) or sticking to their favourite (Mike and Simon). The data suggest that approaching Logo problems in a systematic, reflective manner, with openness to a diversity of methods may provide more opportunities for microworld development.

Summary

An evolving microworld is influenced by many factors. The present study indicated the critical factors to be physical arrangement (pairing), understanding control within Logo, and approach. Collectively, the creation of microworlds appears to be stimulated by cooperative partners firmly aware of their position in the Logo world, approaching problems in a systematic manner.

b) process network - student/student

Microworlds Within a Process Network

A Logo process network is a network arising out of the interaction between Logo microworlds. Therefore the state of one's microworld is vital in the creation of a process network.

Ross's impulsive, fast, transient microworld did not compose well with Simon's world of planning. Simon's organization did not appear to influence Ross: he did not change his approach to dealing with Logo problems during the study. His impulsive behaviour and staccatic control over the situation provoked Simon into the aggressive action of taking over the keyboard instead of working cooperatively to devise a solution. Although Simon worked steadily planning procedures, these procedures were never seriously considered because of Ross's hurried actions. Speed, lack of reflection, and lack of trust in Logo, which limited the development of Ross's microworld also inhibited the production of a process network which would allow increased understanding of Logo.

Alan's microworld was the least developed of those in the study group. His misconceptions about control in Logo and feelings of powerlessness were compounded by his withdrawal

from participation. By removing himself from the system, he was not providing an occasion for his ideas to be considered. This withdrawal contributed to the lack of expansion in the development of a process network. An evolving process network is improbable if one of the parties is not participating.

Although Karen's microworld was built on impulsive ~~ac~~tions and a belief that the computer changed instructions, she was able to generate evolving networks with Logo. Her frustrations with Logo were only inhibiting in the short term. She was unable to function at the time of her frustration but could work at Logo problems during calmer periods. Karen's partner saw her through the stormy periods thereby helping her develop an understanding of Logo functions. Believing that Logo was not trustworthy did not inhibit Karen to the extent that it did Alan and Ross. This in part may have been due to the supportive character of the process network Karen and Jean created together.

Communication

The partner support Karen received contrasted with the situations in which Alan and Ross were operating. In working together, Jean and Karen each had a growing microworld: one approaching situations in a systematic

fashion, the other one working more spontaneously. What allowed an overlapping of these microworlds to produce a process network supportive of each microworld? When Jean saw an inconsistency in their work, she asked Karen. When Karen wondered what approach to take next, she turned to Jean. Words forming questions, answers, explanations, musings, reinforcements, or suggestions, created the interaction between microworlds. This group was enthusiastic in communicating throughout the projects. The information derived from conversation was used in developing their understanding of Logo, and in turn the developing microworlds would be called upon to examine a situation, with ensuing information building upon their microworlds. This percolation of ideas generated continual interaction between the evolving microworlds.

Susan and Anna also enjoyed this spiralling generation of Logo networks as a result of their verbal liaison during computer sessions. Utilizing the information building in their microworld, they would pursue new trends and solutions, creating a shared understanding. A vibrant collaborative system evolved from their verbal discourse.

In contrast, communication for Ross and Simon was a rarity. Consisting of isolated comments and declarations of action, their talk did not meld their microworlds. Ross's claim that he didn't usually talk to anyone about Logo

was indicative of their lack of communication. Since Ross did not seek assistance with the confusion he was feeling over Logo concepts, the misunderstandings remained. By not actively persuing an understanding of a concept through verbal reflection, the growth of their process network and their microworlds remained static. Instead of turning to their partner, pooling resources and sorting out the problem, Ross and Simon searched within their own microworld and when they came up short, went back to the problem, thus creating a short circuit within the process network. A lack of communication was an obstacle in their development of a Logo process network which in turn failed to enhance their microworld development.

Inconsistency was a characteristic of Mike and Alan's talking. At times both parties volunteered suggestions, at times no one talked, while on most occasions remarks were one sided: isolated comments or requests for assistance. With Alan's nonparticipation and an absence of communication, Mike was, in effect, working by himself. Although Mike's repertoire of Logo ideas was growing, he did not have the opportunity to benefit from interaction with another evolving microworld to construct new understandings. The lost opportunity for process network development was, as well, detrimental to the strengthening of his microworld. Being in control of the keyboard, Mike

continued to request information from Alan but was rebuffed, creating a situation which generated friction rather than communication. Communication did not unify Mike and Alan; it became an obstruction to the building of a process network, impacting on microworld enhancement.

Those having discussions concerning their projects managed to build a strong interactive network which enhanced their understanding of Logo, while those who did not communicate could not set up linkages to build upon each other's understandings, thus jeopardizing the creation of a process network. It appears that verbal interaction is necessary in the formation of a supportive Logo process network.

Collaboration

Does collaboration contribute to the formation of a Logo process network?

Once again we had the situation of having two groups who did cooperate, Jean and Karen, and Anna and Susan; and two groups who experienced difficulty cooperating, Ross and Simon, and Mike and Alan. This should not be surprising since working together to solve a problem requires communication. One cannot contribute ideas, suggestions or assistance without communicating.

Unlike Ross and Simon or Mike and Alan, Anna and Susan were also excellent collaborators. Verbal interaction occurred at all stages of a project with information being contributed and evaluated by each participant. They were working together to solve a problem, not allowing the desire for power or competition or other disruptive factors to interfere. Both were equally contributing members of a team. Usually, Anna and Susan did their thinking together: one on paper, the other on the screen. Because of the close cooperation exibited by Anna and Susan, a sharp division of roles was not evident, making the perception of equality easier to maintain. While working on the division of a rectangle (assignment #6 - see Appendix A), Anna became so involved with her solution that she forgot to include Susan, who resented being excluded.

They have been experimenting with colour.

?paint1 (a tiny bit of blue on the other side)

(long wait)

[A is drawing and pointing to the screen]

R "I see what she is doing."

S "I don't!"

[Anna continues to try out her idea of dividing the rectangle into many pieces without explaining what she is attempting.]

The resentment Susan felt because she was not involved in the decision making for this project, was indicative of the feelings which could be evoked by a lack of collaboration. If Anna continued to experiment, providing no access for Susan, conflict might errupt with Susan demanding to be involved, aggressively taking over, retreating from involvement, or beginning her own project, none of which would contribute to the formation of a process network. Collaboration involves the voluntary pooling of concepts and verbal negotiations involving these concepts, building a strong communicative network.

Although Jean and Karen did cooperate on their projects, they demonstrated a more sharply divided separation of roles than Anna and Susan which led to some predicaments. When Karen, who controlled the keyboard, didn't listen to Jean's ideas, Jean insisted on being heard which detracted from the formation of a productive process network. Often, Karen didn't follow along while line by line editing was taking place as if that was Jean's job, indicating that the blending of roles for a team effort was not always an occurrence. Both participants volunteered ideas, implementation of which appeared to be fairly distributed.

appeared to be distributed fairly. When a clash of wills over opinions was imminent, resolution was achieved by the girls moving to separate computers. Separation, allowed them to cooperate and avoid the conflict which was present due to constant pairing. Jean and Karen were treading a fine line between cooperation and disruption. To preserve their working relationship, they sought a partial separation by working at separate computers, an organization which suited their particular needs. Cooperative efforts and communication were reduced by the physical separation of the partners but the cooperation resulting from this partial partnership was sufficient to at least maintain, if not enhance, the process network.

Communication between Ross and Simon was even lower in collaboration. This group operated with a complete separation of roles: Ross at the keyboard, Simon as planner. Normally, Ross did his own thing without talking and explaining his actions, which provoked Simon into pushing Ross aside in order to try his ideas. Having gained control of the keyboard, Simon would try his plan without any explanations. In effect, they were carrying out separate investigations. With little communication in place, any opportunity for collaboration would be difficult. Nevertheless, on March 9, they had a brief fling with cooperation:

(observation)

They began by putting up the solution (rectangle divided on the diagonal) from the last day.

Simon had the next procedures worked out and written in his book.

They made the rectangle with 2 diagonal lines and 2 parts coloured with a border.

They were very proud of this and called me over to show me what they had done.

[Ross made a suggestion of what to do next and Simon made another one. They tried Simon's]

Partway through, Ross says "no it's like this - we want to go through the middle"

At this point after cooperating successfully throughout the period, Ross revised the approach, giving a limited explanation which resulted in Simon isolating himself until Ross asked for information. Cooperation between the partners was short lived, the familiar pattern of separation returning during the next experience. The absence of collaboration coupled with the lack of communication provided an effective block to the establishment of a process network.

Mike and Alan also exhibited little ongoing cooperation. When Mike was looking for help, he wanted information to plug into his concept, which left Alan feeling unimportant and he withdrew. Collaboration was unlikely since Mike operated as if he required an assistant rather than a co-worker and Alan could not be relied upon to participate. They did not function as a team working on a solution, a fact which could have contributed to the absence of coherence in their process network.

In all the groups when collaboration was not present or waning, frustrations arose which were detrimental to the development of a cohesive process network. Conversely, collaboration with participants feeling equal and productive did lead to the development of a cohesive process network.

Pairing

Collaboration which is instrumental in building coherence in a process network also can activate the advantages of pairing. Pairing produced a dominant person in each group who determined the direction taken by controlling the keyboard. Anna and Susan alleviated the domination by equalizing the power through collaboration, while Jean and Karen may have shifted the balance of power by moving to separate computers for part of the time. Domination of the keyboard by one person in the other groups led to

friction, creating serious communication and participation difficulties which were obstacles to the formation of Logo systems at all levels.

Even within groups as harmonious as Susan and Anna's, care had to be taken to explain actions. Otherwise, the resulting anxiety could lead to confusion and a deteriorating network. Susan's growing confusion and resentment when Anna began experimenting on the rectangle division, without giving any explanation for her actions, highlighted the fragility of a process network. Karen expressed another concern in the need for constant explanation to a partner when listing an advantage of working alone as "not having to explain everything you do". In adapting the structure of their group to their individual needs, Jean and Karen pointed out the need for individual solutions. In the present study, working in pairs did not appear to be an advantageous structure for the majority of groups. The dynamics of the pairing produced factors which were obstacles to the development of Logo systems for three of the groups. Anna and Susan were the only participants to reap the benefits of pairing: their process network evolved quickly in paired conditions. Jean and Karen managed to survive and create a process network through reorganization. While every group is unique and requires separate arrangements, perhaps Jean

and Karen's organization of working on adjacent computers was a compromise which takes advantage of the benefits of pairing and nonpairing.

As well as providing a forum for the generation of thought, pairing provided an opportunity for modelling appropriate strategies. Jean successfully modelled techniques for Karen but Mike did not appear to have any effect on Alan, or Simon on Ross. For Karen and Jean pairing also provided occasions for Jean to assist Karen which resulted in increased understanding but when Mike attempted to assist Alan it generated conflict rather than understanding. It appears that pairing could facilitate the generation and extension of ideas, modelling of effective strategies, and assistance in general but the effectiveness is modulated by the nature of the process network. Communication and collaboration were the ingredients necessary to produce cohesion in a process network. If these components are present, some of the advantages of pairing could be enhanced.

Reflection

The synergetic relationship, produced in a Logo process network, was developed through collaborative discussion during which thoughts built upon each other creating a

concept- rich network. Susan and Anna are involved with assignment #3 (see Appendix A).

A "Let's make another letter"

How high should I make it?"

Anna suggested a new direction and asked information of Susan who might have an idea of the height because of her planning. In this case, seeking advice from Susan enriched Anna's microworld by forcing her to look elsewhere in making a decision.

S "I don't know yet. I'm still drawing"

?TO HI

A "It will have to be 5"

Make it 2 spaces in the middle"

When Susan delayed answering, Anna called upon her own resources, suggested 5 and then had another proposal for the diagram. She was calling upon previous knowledge to arrive at her estimate which may have been an additional approach to Susan's.

S "Okay" (she keeps on drawing on grid paper)

A "Where are we going to start it?"

(S counted the spaces 5-10-15-20-25)

Once again Anna turned to Susan, who because she was reflecting on paper, was the best source of information for the question. Susan counted the spaces on the grid paper and this formed the basis of the command.

>FD 25
>RT 90 FD 5
>RT 90 FD 10
>LT 90 FD 10
>LT 80 FD 10

A "Write this down"

>RT 90 FD 5
>RT 90 FD 25
>RT 90 FD 5
>RT 90 FD 10
>LT 90 FD 10
>LT 90 FD 10

S "Wait a minute hold on!"

Susan perceived a problem and introduced her perspective to the proceedings. In this case Anna, on her own, would

have continued the commands, having to sort it out afterwards.

[They talk their way through the instructions]

S "But where is it?"

>RT 90 FD 5

>RT 90 HT

>END

?HI

S "I'm going to see if you have the same thing"

[Susan reads the written instructions while Anna checks]]

The melding of Anna's knowledge gained through previous experience and visual sources with Susan's information on paper and from visual comparison created a network richer in knowledge and strategies than would have evolved separately. The network was richer as a result of containing Anna and Susan's knowledge and strategies and the concepts built out of the ideas and techniques.

How is reflection involved in this process?

As illustrated in the above episode, ideas which emerged from reflection were the very ingredients from which the

synergetic relationship was built. The concepts to be considered were expressed then evaluated for the job, and a decision made. The reflection completed during this process expedited the construction of a process network. The reflection was collaborative in nature, optimizing growth in the network. On the other hand if the participants worked at odds with each other, opportunities would be lost and the potential of the system decreased. Reflection added to the synergetic relationship by introducing thoughts derived through varying strategies or mediums, providing alternatives in perspective thus enriching the network.

Summary

Talk was critical to the formation of a process network. But it appeared that talk was not enough: this talk must also be communicative. The two groups who developed viable process networks, employed talk as a regular reflective method. Once dialogue was established the other reflective methods were valuable in furthering a network but were useless without collaboration. Collaboration brought equality and a pooling of resources to communication. Ideas were shared, acted upon and developed into a mutual experience. Shared experiences allowed the process network to take shape. These actions and concepts formed jointly and shaped by the interaction of continually evolving microworlds,

became components of a synergetic network created in the process of solving a problem. As collaboration continued and new ideas arose, a coherence developed as a result of the convergence of purpose. Group members came to share purpose and experience.

Summary

A generative process network emerged as talk became communicative, with collaborative action generating a coherence within the network. The resulting generative process network was a vibrant system generated through communication becoming collaborative.

In level one reflection, talk was associated with expanding microworlds. Verbal communication was the linkpin of level two reflection. Collaborative communication between group members established linkages which created coherence among components.

Anna and Susan created this form of process network. They reflected through talk; talk became communicative as they shared their ideas cooperatively; their communicative action became collaborative as they engaged in mutual problem solving. The shared experience drew the participants closer, producing a coherence of purpose - a generative process network.

c) process network - student/student/researcher

Anna and Susan

When the researcher entered the collaborative process network built by Anna and Susan, she was accepted as a co-worker. The researcher did not become an integral part of the group on the first encounter, but as trust was established so was the relationship. The process network was built out of the free flow of ideas, which through interaction produced further ideas generating experiences which were exciting to all the participants. These common experiences were developed through three - way conversations in which all opinions received attention and evaluation; any member contributed ideas for discussion; and any member, not only the adult, explained concepts (for an example see pg. 87-89). A collaborative process network developed out of the girls' existing process network. The experiences shared by the three members created a generative process network involving the researcher.

Examining the researcher's comments during the conferences reinforced the notion that the process network being developed was a collaborative three way conversation, in that concept facilitating types of comments were made: questions (135), suggestions (97), explanations (57), and confirmations (66). The data indicated that the researcher

did not restrict involvement to questioning: the interaction had variety and was discussion based. Sometimes a conversation began with a probe:

R "What are your plans? What are you going to do with it?"

A "Write a name."

S "But first we have to find out how to do an R."

R "Well what do you think you're going to do?"

A "Like that (diagram) sort of"

S "I think all it would be doing is just a 45 degree angle and also this length might be a problem."

A "You have it in your book."

R "But you're right it might be a problem. This part doesn't look like it's any problem, right?" "And you are sure you want it to be partway here?"

A "Oh, I think I know why"

(drawing on the grid paper)

R "Oh I see. So you would have to do a little experimenting, I guess, to see exactly whether this

is.....if these were 5 then it is about halfways. You would have to decide whether you are going to go 2 or 3."

S "or 2.5"

This conversation began with a general open question followed later by a more task - oriented query. As the participants were talking, the researcher reaffirmed their ideas and then asked about an inconsistency she had noticed. When this was explained, the researcher made a suggestion, followed by Susan's idea. The researcher used the probing questions in order to spur further consideration of ideas. When this reflection was occurring, the comments turned to explanations and reaffirmations of other ideas.

"Could you do any thing else?" or "Do you have any idea why you like doing that?" Probings were often this open ended type of question intended to extend thought into untried areas. Sometimes the probing was intended to channel thought towards one idea. "This way, so this way and you want it to go all the way around to face this way (pointing)? So it would be....." On other occasions the researcher was seeking an explanation of an action taken by the participants at the computer. "Then you wanted this one to be over here, right? Why would you

repeat 23 of these, because you are going to end up with them all the same?" The types of questions posed by the researcher did not fall into the traditional classroom category of testing information in which the questioner already knows the answer. Conference questions often said "have you looked at this idea another way?" or "are there reasons for this happening?" or "let's explore this area". On the occasions that the researcher was funnelling thought towards one solution, it was as a result of her discovering a method of solution, whereas on other occasions other members were explaining solutions. On March 2, Susan tried to explain that the inclusion of a setheading command was the problem:

S "You know how we have setheading 90. Ok, watch it. Setheading 90 and now that part's right and setheading 90 again."

R "Let's look at it and see what she means."

S "There's a setheading 90 here and down here too."

(they go through one step at a time)

R "Now I know what she is talking about - in the middle of the procedure it's going to say setheading 90 (no matter where the turtle is pointing) and it screws up the whole thing, right?"

While another time, the researcher used probing to induce an explanation.

R "When you first tried out shapes to see whether they would tessellate. Did you find some that didn't work?"

A "I think we tried one, we had a triangle and then we tried to put squares on the side. Except then it didn't work because you can't have another triangle in there."

R "That's right. There isn't enough space and they sort..."

A "And what's there..You can't put a square there because it's not....it breaks the pattern. And then we tried a square with triangles around it."

S "That works"

R "And this one (hexagon with squares) works. This is one of the things I wanted to look at because this has 4 sides with 4 things on it. I think this is a pretty general rule, but it seems that it has to be an even number here. Because the 6 works with 6..."

A "and the 4 works with 4."

R "but it doesn't work with 5."

In both cases the participants were pooling their experiences to knead a new understanding, thereby building upon the emerging process network.

In instances when the researcher was required to probe into the participants actions for clarification, the interaction brought the researcher back into the group and provided a time for the participants to rethink their activities. Although these enquiries may have been useful in arranging for reflection on actions, they also pointed out the fact that the researcher was not an involved third group member at all times. Questions were sometimes necessary for reorientation into the group.

Even though the researcher was involved in a three way discussion which seemed to produce a viable process network, the researcher posed the questions. Several times the girls introduced topics that they felt needed consideration but generally the researcher instigated the discussion with a question. Why? To begin with the researcher did have control over the situation in having arranged the conference; its time, place and purpose. The perception that the adult was in charge could have been perpetuated by the circumstances of the researcher picking the students up at their classroom, taking them to another room, and beginning the conference by replaying the videotape of their computerwork. Over time the

formality of the structure was overcome and the researcher assumed a collaborative role in the group.

Another factor which may have influenced their perception of the researcher's role was their past experiences with teachers. Teachers ask questions, control students' ideas, don't listen to students, and as Anna put it "have old fashioned ideas", In other words they cannot be trusted. It takes considerable time to change these perceptions. Students must discover whether or not it is safe to ask questions. Will their ideas be valued? Does this adult know anything worthwhile?

It was not surprising that the researcher asked the questions because that was the expectation but during the course of the study this format was breaking down and there was more variety. By raising topics for discussion, the students were indicating that the conference was a safe place to think.

Did the process network generate common experiences and expanded concepts?

R "Could you put that all together, into a procedure, and it would fill up the whole screen?"

S "Yes, you could say repeat whatever."

A "You could put everything together and then you just press a certain thing and you'd see all of it."

R "How many times do you think you would have to repeat it?"

S "5"

R "Why did you pick 5?"

S "It's half of 10."

R "Well that's a good enough reason. Yes, this was supposed to be 10."

S "No it's 100"

R "Oh, it's 100, but you would get 10 and they are 20 high so you would get 5. So if you put repeat 5[LSrec bk 20 lt 90]"

S "no that wouldn't work. You have to say, before you said LSrec you would have to say forward 20 and then do that."

During this conversation, the concept of using a repeat command and the order of use was built up through the interaction of the three group members. The concept of utilising the REPEAT command to make one overall procedure was employed several days later to produce five rows of

squares. Concepts were expanded and common experiences were being generated because the process was collaborative. A generative process network did evolve because the researcher was gradually accepted as a co-collaborator. By collaborating with Anna and Susan the researcher was able to contribute towards the solution, resulting in a feeling of group accomplishment when the problem was solved.

The evolving process network provided opportunities for the effective strategies being used to be reinforced.

R "And I really notice that there are several things that you do all the time, to make it easier. Can you think of anything that you might do that makes it easier for you to work on a problem?"

S "You make a picture of it."

R "I noticed that you do that, really consistently. And what else do you do?"

A "Turn the thing (Book)."

R "Yes, I thought that was a good method. I guess sometimes you want to take the pencil and actually count them or whatever. I really noticed today that you are turning it around."

S "Because you have to make sure if it's rt 90 or lt 90. Cause you don't want to get them mixed up or else it won't work."

R "Now the other thing I noticed that you did was on the screen. You actually went through the procedure line by line, looking at it carefully and it seemed to help you."

Identification and reinforcement of effective strategies may be important if, as according to Garofalo (1987), an awareness of reflective methods is necessary for the development of metacognition.

The process network also provided a forum for modelling strategies, such as drawing diagrams and line by line editing.

Because of the strong collaborative nature of the communication within the group, a process network was generated in which a sense of coherence was developing.

Mike and Alan

The process network that developed during the conference time with this group differed greatly from Anna and Susan's network. Since Alan had generated a restricted microworld, thus limiting his interaction with Mike, a stable process network did not exist for the researcher to enter. Although the researcher attempted to begin by posing general questions, the responses were limited and did not extend the idea. Responding appeared to be the end not the beginning.

R "Did you have any problems with what you are doing?"

M "A little bit, trying to figure out. This one is green and this one is blue. You can't do that."

At this point no one interrupted with an idea or questioned the statement: the case was closed. The conference moved into a traditional seminar format. Questions were asked based on the researcher's assessment of the difficulties the students were experiencing, until a strategy was developed, and then guided practice was provided. In working on their monogram (assignment #4 - see Appendix A) the following conversation took place.

R "What does the variable do when you put it in there?"

M "You could change the size."

R "What is the first thing you would have to do if you were going to put the variable in?"

M "Put size at the top."

.

.

R "What is the next thing that we are going to have to change?"

A "The angles"

R "Are we going to have to change the size of the angles ?"

A "On the A we have to..."

R "That is something different. But what are you going to have to change if you are just changing the size of something?"

M "The amounts that you are going forward."

R "Ok, so where is the first one."

M "Right there? I'm not sure, would you go backwards?"

R "Well, is going backwards going distances?"

M "yeah"

After working through some more they devised a plan and wrote it on paper which was used during the next two computer periods. During this conference the researcher probed and the students answered and the process continued. The conference dealt with difficulties the students were experiencing in their project. With this group, generally, the conference dealt with misconceptions rather than extending thought to new ideas and the students relied on the researcher to sort out their difficulties.

In contrast to Anna and Susan, by default control of the situation was retained by the researcher throughout the study and a working group with equality for the members did not exist. Rather the researcher struggled to keep both students responding, no matter what their attitude had been in the computer room, and facilitate the development of Logo concepts. Having the responsibility for the functioning of the conference resulted in a hierarchical structure with a disproportionate number of questions asked by the researcher (227), in comparison to (60) explanations and (60) suggestions.

Although a collaborative process network was not generated, the knowledge base that was established through interaction was valuable to Mike and Alan in developing an understanding of Logo functioning. The ideas pursued in the

conferences were used in their computer work. Opportunities were provided for the modelling of successful, reflective strategies and assistance could be provided.

A comparison of the groups

Although Anna and Susan created a collaborative process network with the researcher, while Mike and Alan did not, both process networks were useful to the participants. They both developed concepts which were new to them and generated ideas which were applied to the computer work. The difference could be in the sense of ownership, an important concept to Anna and Susan. Similarily, the researcher felt an ownership with the ideas developed with Anna and Susan. She often felt that sense of accomplishment which comes from turning new ground when a commonly developed thought was fruitful: a sense of involvement. This feeling of coherence was absent in working with Mike and Alan. The sense of being connected with the decision was missing: elation was not experienced, only satisfaction that they had made progress.

Anna and Susan's interaction with the researcher developed into a collaborative process network. The group's talk which began with the researcher posing questions quickly became dialogic. Communication of ideas arose when the

researcher's questions triggered a discussion rather than simply an answer. Responding to the question was not the end, as with Alan and Mike, but the beginning of an exploration. As the interaction proceded, the communication took on a collaborative aspect. At this point Anna, Susan and the researcher became partners, investigating with Logo. The emerging process network acquired coherence, a sense of togetherness, after operating for awhile. Coherence was evident in the sense of commitment and ownership the group members felt towards the concepts generated by the collaborative network.

This feeling of coherence, of working together towards a mutual goal was missing in the network developed by Alan, Mike and the researcher. Talk did occur and become communication, an exploration of an idea, but this communication was directed by the researcher and was much more one directional than any conversation with Anna and Susan. Questions went out from the researcher to one of the boys and answers were returned. The discourse did not acquire the sense of purpose which existed in the network established by the Anna and Susan. A conversation with Alan and Mike was like playing "catch" rather than being in a whirlpool with Susan and Anna where ideas were churning and mixing and in which collaboration was strengthened and coherence generated.

Why was there a difference?

Anna and Susan had created a vibrant process network between themselves and their communication was effective. The researcher found it easy to move into this network on a collaborative basis. Through a low level of control within Logo and diminished communication, Alan and Mike had not developed a cohesive network. Without the framework in place, the researcher found it impossible to generate a collaborative network. Attempts were made to have the students comment or add to their partner's suggestions, but remarks continued to be made through the researcher. Perhaps, they viewed the role of an adult in a different fashion: Anna and Susan were able to accept the researcher as a partner, while Mike and Alan saw only authority. Differing experience in small groups could have affected their opinion. Since Anna and Susan were self - initiated learners, they would have undergone this kind of learning previously, whereas, Alan and Mike might have been new to self - directed learning.

It appeared that for a collaborative process network involving the researcher to be generated a healthy microworld and cohesive process network needed to be intact.

A Comparison of the Conferenced and Nonconferenced Groups

More signs of frustration were exibited by the nonconferenced groups (27 and 51) than the conferenced groups (22 and 6) (see Appendix E). Discussion concerning the topic of frustration with a facilitator would alleviate some of this frustration and prevent it from becoming constant and debilitating. In Alan and Mike's case the conference dissipated their feelings of frustration, replacing it with a degree of understanding.

A "To.....dumb"

```
to dumb
sq
tri
fd 30
sq
tri
fd 30
sq
```

(got this far and decided to use repeat)

```
to dumb
repeat 4 [fd 30 sq tri]
```

M "We should plan."

A "Oh well, we're making a square and a triangle"

?cs

?dumb (line and then 4 shapes)

?ed (talked through the instructions)

A "It's probably going to think it has 4 sides."

M "You said fd first"

to dumb
repeat 4 [sq tri fd 30]

(changed the order so the move is last)

A "You didn't put in end" (M puts end in)

A "You shouldn't say repeat 4 but repeat 3 and then add lt 90 - oh no it won't work with repeat"

At this point in Mike and Alan's attempt to make shapes that were joined to each other, their procedure title expressed their feelings. Their frustration and lack of progress was maintained throughout the class. During the conference the researcher used pattern blocks to connect the idea of patterns in a repeat command. Mike and Alan practised making procedures for shapes using the repeat command and the combination of a repeat and move procedure. The following day they attempted to make a

procedure which would repeat shapes but they had difficulty with the move and became frustrated again. A partial solution was reached following the conference. Without the development provided in the conference, Mike and Alan would have been struggling to understand the repeat command and perhaps have quit trying.

While the conferences helped Alan control his frustration and the group maintain a working situation, Anna and Susan were assisted in expanding their horizons, focussing on an area of difficulty, retaining a collaborative atmosphere, and were assisted in dissipating any building resentment. Similarily, the nonconferenced groups could have been assisted in their understanding on many occasions by talking with a facilitator. Ross and Simon's misconceptions concerning the edit mode might not have become critical to the development of Logo ideas if they had discussed the idea and sorted out the difficulties at the beginning. Karen may have been able to work out some of her misunderstandings about control within Logo which limited her growth. The strength of some strategies could have been pointed out and modelled for Ross and the discussion of a conference setting may have initiated some discussion between Ross and Simon which would have influenced the direction of their systems evolution. Jean and Karen could have benefitted from an assisted attempt

in developing a collaborative process network out of the communication that existed.

The researcher attempted during conferences to highlight reflective methods the students were using. The emphasis on reinforcing methods of reflection seemed to be effective in that the conferenced groups were more aware of the reflective methods they employed and in some cases the best situation in which to use them.

Summary

The process networks that developed and involved the researcher, were very different. With Anna and Susan a cohesive process network was generated, while with Alan and Mike control of the communication was retained by the researcher. Benefits of the conferencing were evident in the development of ideas, increased use of reflective methods, and the working through of frustrations. Although both groups did not create collaborative relationships, the conferences provided assistance to both groups.

CHAPTER SIX

CONCLUSIONS

This chapter is a summary of the findings presented in the previous chapter. The summarized findings are then applied to the research questions. Implications of the research and suggestions for further study conclude the thesis.

SUMMARY

The two levels of reflection referred to in Chapter Three (level 1 and two situations of level 2) were detected in the data and could operate as viable forms of reflection. Level 1 reflection, a microworld, was developed to various extents by all participants. The emerging microworld became embedded in level 2 reflection to produce a process network. The most developed process network emerged through a generative process, involving five factors. These components were talk, cooperation, communication, collaboration and coherence. A process network's generation began with talk at the microworld level. Cooperation amongst the participants directed this talk towards the next step in the emergence of a network, communication. Having achieved a communicative state, collaboration amongst the participants needed to be attained before a new dimension arose in the development. Once a collaborative network had been

formed, coherence, or a sense of unity, ensued as a result of the operation of the process network.

THE RESEARCH QUESTIONS REVISITED

What is the nature of reflection in an interactive Logo network?

Reflection in an interactive network is encompassed in a generative process network, modelled as follows.

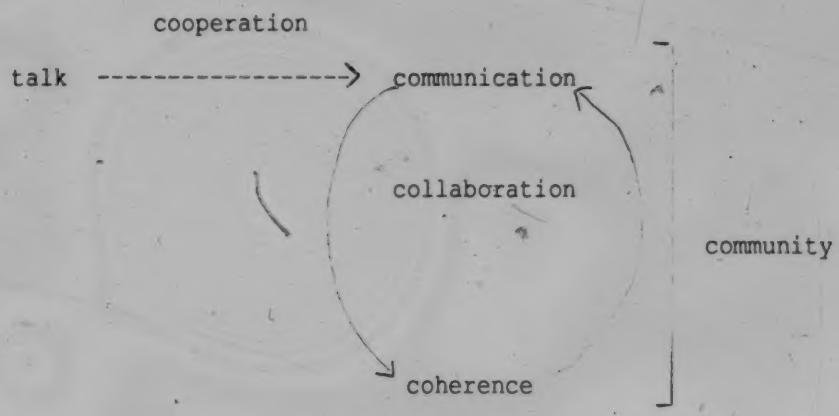


Figure 11: A Model of a Generative Process Network

Talk, occurring at the microworld level, involved Level 1 reflection; information was requested, opinions sought or ideas questioned. The individuals interacted with Logo through talk in an attempt to further their individual direction. The talk of individuals attained the level of

communication through cooperation between participants, knowledge was shared and assistance given. Through cooperation talk began to resemble a dialogue with the normal "give and take" of a discussion. Once talk was transformed into communication via cooperation, level 2 reflection was involved. As in Jean and Karen's case, verbal discourse could maintain the link between talk and communication through cooperative activity. To move microworlds into the realm of level 2 reflection within a generative process network, collaborative processes needed to be operating. As illustrated by Anna and Susan's experience, réflection through the pooling of ideas on an equal basis produced coherence. This sense of common purpose or unity allowed for the generation of continued communication which collaboratively produced increased coherence. Common experiences were generated recursively within this network, producing a reflective community.

Anna and Susan built a self-generating network through collaborative reflection. On the other hand, when the verbal interaction remained at "talk", development only occurred at the microworld level. As cooperation produced communication, a process network was beginning to be created and as a result of the spiralling growth of a process network, the microworld was also supported. With the incorporation of collaboration into communication came

an evolving process network which further strengthened the microworlds involved.

In the development of a generative process network, (1) talk becomes communicative through cooperation; (2) communication becomes cohesive through collaboration; and (3) coherence becomes community through recursion.

a) How is reflection embedded in a Logo process network?

i) **microworld**

Reflection produces material (knowledge, theories, feelings) from which a microworld is created. Every method of reflection produces information which is reflected upon to arrive at a decision concerning future action, which is subsequently reflected upon. As this cycle continues, concepts build up creating a microworld. Reflection is the core of this recursive activity. Although reflection is not the sole factor influencing the development of a microworld, it is a synthesiser of ideas. Factors influencing microworld development are directed to the microworld by reflection whether it be level 1 or 2. The most important factors in microworld and therefore reflective development were:

* **reflection itself**

If the Logo user did not reflect upon the effects of an action and evaluate the resultant information, concepts were slow to develop and microworld growth remained static. In contrast, the use of a variety of reflective methods to gather information was very productive.

* **control within Logo**

An essential component for a smoothly developing microworld was an understanding of one's control within Logo. Students who thought the computer played tricks on them, reversed their ideas or did not do as it was commanded, did not feel that they had any control over their ideas and did not develop viable microworlds. On the other hand, participants creating evolving microworlds knew that control of Logo was in their hands. They were aware that difficulties could be rectified and accepted the responsibility for discovering solutions.

* **pairing**

In the present study, the pairing of students was a critical factor in microworld development. For Anna and Susan working in pairs was advantageous in strengthening their microworld and process network evolution. Their collaboration created a synergetic relationship. In

contrast, the friction which arose between Alan and Mike hampered attempts of theory building and interfered with the development of microworlds. Pairing created a "doer" and a "planner" which forced a predetermined structure upon the group, influencing the individual's relationship with Logo. But pairing also provided each group with the opportunity to share ideas which could enhance microworld development.

* **talk**

It appeared to be important to employ a variety of reflective methods in building a microworld, but talk was critical because it could not only enhance development at the microworld level but could also generate a collaborative process network, which in turn produced microworld growth.

* **systematic approach**

Students who did not have a plan of attack, impulsively attempted any method of solution, or did not take the time to reflection upon a situation had a difficult time in developing a growing relationship with Logo. In contrast, those students who (1) allowed sufficient time to evaluate the situation, (2) had several reflective methods to use, and (3) approached the problem in an organized fashion, had evolving microworlds.

ii) **Process Networks**

Two process networks (student/student) and (student/student/researcher) were examined. These networks were generated in the same manner.

A coherent process network was a reflective forum. The network was generated by reflection occuring collaboratively. Talk used for reflection became communicative during reflection on concepts through cooperation. When this communication became collaborative, a generative process network was forming. A cohesive process network was alive with reflective activity, generating evolving concepts. By working collaboratively Anna and Susan were able to generate a cohesive process network within which to solve Logo problems. Similarily, because they were operating collaboratively they were able to create a cohesive process network with the researcher.

Without collaboration partial development occurred as in the case of Karen and Jean. Through discussion they were developing their microworlds and beginning to develop a process network cooperatively but without collaboration coherence was absent. In the noncollaborative situation, microworlds were created but within the process network reflection did not become self-generative.

b) What methods do students use to solve their Logo problems?

The most commonly used methods of reflection were guess - check - adjust (GCA), experimentation (GCAexp), line by line editing in the immediate mode (E), and talking. Other useful methods were drawing and writing, checking the turtle's direction and waiting. It appeared that students employed the methods of reflection requiring direct contact with Logo in greater numbers than those methods performed at a distance.

c) How does the researcher's emphasis on reflection influence the student's work?

i) **collaborative network**

In the cohesive process network generated amongst Anna, Susan and the researcher, the resultant reflection emerged as another level of process network which through the recursive nature of a process network strengthened each participants' microworld.

Since reflection created a generative process network, a community of learning, the emphasis on reflection generated a learning experience for those involved. The development of the process network involving the researcher had a positive influence on the students work as evidenced by

the follow through of ideas developed during the conference.

ii) **noncollaborative network**

Alan and Mike were assisted with their work. Concepts were developed during the conference which would not have been possible within the computer period. Ideas introduced during the conferences appeared in subsequent work.

In both groups, the emphasis on reflection created an increased awareness of the methods of reflection, of which methods they employed, and of which methods were effective or appropriate in a situation.

IMPLICATIONS

Teachers, searching for ways of involving students in a variety of problem solving situations, could look to Logo for experiences in applying the guess and check method of reflection. The use of Logo offers the opportunity for other less "natural" methods of reflection to be modelled. Since guess - check - adjust, experimentation, and line - by line editing appeared to be the "natural" or inherent forms of reflection, other methods of reflection which could enhance learning such as writing, drawing or checking previous work would require emphasis.

Collaborative learning situations could be generated through Logo experiences. The generation of a collaborative network relies on the formation of communication and coherence through collaboration. Situations could be devised to emphasize cooperation and collaboration; for example groups of students, required to produce only one solution or gathered to share and discuss their work etc.

Physical arrangements which maximize the opportunities for sharing through discussion need to be provided. This might involve a grouping of computers, a grouping of students, or a provision for sharing time. Since communication is essential to generative process network development, teachers may need to adjust their current practices to accommodate communication and collaboration.

A collaborative process network "emerges" and cannot be expected to appear immediately. Teachers can only hope to facilitate development not guarantee learning and therefore need to be patient: development will occur but time lines cannot be specified.

In Logo experiences, extended discussion with an adult appeared to assist understanding whether the child was involved in generating a process network or was just beginning to develop a microworld. In order to maximize

learning in a Logo network, teachers should take advantage of opportunities for observation and discussion.

Is the grouping of students advantageous for Logo experiences?

It appears that the pairing of students might be advantageous to the generation of a collaborative process network because communication is essential for development. The availability of a permanent collaborator increases the opportunity for communication. On the other hand, pairing of students can produce conflict amongst group members thus reducing the effectiveness of reflective development. Perhaps a variety of arrangements could be employed such as individual work, larger groups, a rotation of partners, the pairing of two students with two computers, or a rotation of the group roles.

SUGGESTIONS FOR FURTHER RESEARCH

1. Since a cohesive process network appeared to be developed through a Generative Process Network model, application of the model to Logo process networks would generate a greater understanding of the emerging process network.

The Model of a Generative Process Network as illustrated in figure 11 (pg. 167) could be applied to any developing network. These networks might exist in any area where cooperative learning is desired. Opportunities for this sort of examination exist in group situations in Social Studies, writing conference groups or problem solving situations throughout the curriculum.

2. The results of the present study suggested several factors which seem to be critical in the development of a microworld, Level 1 reflection. The student's control within Logo, the physical arrangements, the use of a systematic approach, and the level of verbal discourse could be examined in relationship to the development of a microworld.

3. The present study concentrated on Level 1 reflection (context Level 1) and the process network (context Level 2) of Level 2 reflection (Figure 1 p. 25). An area for

further research would be contextual Level 3 (educational context). An examination of a community of learners within which a cohesive process network is embedded would add to the knowledge concerning the generation of collaborative networks within a classroom.

4. Emihovich and Miller (1988a & b) and Au, Horton and Ryba (1987) were investigating teacher intervention designed to stimulate metacognition in Logo. In this area of teacher intervention, further study is required into the teacher related factors affecting conferences or other situations in which process networks emerge. An examination of teacher questions and interaction or the teacher's approach to the conference might uncover additional helpful characteristics of collaborative process networks.

5. It is interesting to observe that the groups who were most successful in generating process networks consisted of girls while the groups which encountered difficulty were composed of boys. Further study is required in the area of gender effects in the generation of collaborative networks.

6. Vygotsky's (1978) premise that learning is facilitated by a more experienced learner sharing knowledge with a less advanced learner is reinforced by the present study. Alan and Mike took advantage of the availability of a

more knowledgeable person during the conferences. Similarily, with Anna and Susan the person who was the most knowledgeable at the time provided the scaffolding needed for the evolution of a concept. Since members of this group exhibited equal control, the more experienced learner varied according to the problem. Of course an adult did not always need to be involved in this process as in the case of Karen learning from Jean. Azmitia (1980) would agree that working with an expert can maximize learning. Further study of these ideas as applied to Logo networks or other collaborative communities would expand our understanding.

7. "Metacognition refers to the knowledge and control one has of one's cognitive functioning, that is, what one knows about one's cognitive actions during performance" (Garofalo, 1987,p.22). Students must be aware of the reflective methods they employ in order to control their thinking and make the most effective use of their knowledge.

The most reflective group, Anna and Susan, had the highest consistency between awareness and methods used. They appeared to be cognizant of the methods and able to use them to the best advantage while Ross and Simon, who experienced difficulty with Logo, had a hazy understanding of the techniques and their utility. The present study indicated that students were aware of the reflective

methods that they use to solve Logo problems and highlighted the contention that "since metacognition has to do with awareness, its development requires one to observe what one does and to reflect on what one observes" (Garofalo,1987,p.22). Anna and Susan had become aware of the advantages of certain strategies through continual observation and reflection. The connection between cognition and awareness of methods for optimizing cognition is an area needing further study.

8. Within a generative process network different kinds of talk, referred to as talk and communication, were produced. Communication was the conversation produced through cooperation and which could be involved in the building of a process network. Although a two-way dialogue could evolve if the speakers cooperated, it was not until they collaborated that a cohesive communication network could be built which generated a community of thought. Is "talk" similar to "exploratory talk" (Barnes',1976,p.28) in which the user is searching for meaning or "regulative language" (Rosen&Rosen,1973,p.72) used to impose social order? Does the language employed change once it becomes "communication"?

Analysis of the oral language of children developing a Logo process network could be undertaken.

REFERENCES

Au, Wing Kee, Horton, Jane, & Ryba, Ken (1987). The Computing Teacher, 15(3), 12-16.

Azmitia, Margarita (1988). Peer Interaction and Problem Solving: When Are Two Heads Better Than One? Child Development, 59, 87-96.

Barnes, Douglas (1976). FROM COMMUNICATION TO CURRICULUM. New York, NY: Penquin.

Becker, Henry Jay (1987). The Importance of a Methodology That Maximizes Falsifiability: Its Applicability to Research About Logo. Educational Researcher, 16(5), 11-16.

Calkins, Lucy McCormick (1986). The Art of Teaching Writing. Portsmouth, NH: Heinemann.

Campbell, Patricia F. (1988). Microcomuters in the Primary Mathematics Classroom. Arithmetic Teacher, 35(6), 22-30.

Clements, Douglas H. (1984). Effects of Computer Programming on Young Children's Cognition. Journal of Educational Psychology, 76, 1051-1058.

Clements, Douglas H. (1985). Research on Logo in Education: Is the Turtle Slow but Steady, or Not Even in the Race? In Maddux, Cleborne D. (Ed.), Logo in the Schools (pp. 55-71). New York: The Haworth Press.

Clements, Douglas H. (1986). Effects of Logo and CAI Environments on Cognition and Creativity. Journal of Educational Psychology, 78, 309-318.

Clements, Douglas H. (1987). Longitudinal Study of the Effects of Logo Programming on Cognitive Abilities and Achievement. Educational Computing Research, 3(1), 73-94.

Cobb, Paul, Merkel, Graceann, Wheatley, Grayson, Wood, Terry, & Yackel, Erna (1988). Arithmetic Teacher, 36(1), 46-47.

Emihovich, Catherine & Miller, Gloria E. (1988a). Learning Logo: The social context of cognition. Journal of Curriculum Studies, 20(1), 57-70.

Emihovich, Catherine & Miller, Gloria E. (1988b). Talking to the Turtle: A Discourse Analysis of Logo Instruction. Discourse Processes, 11, 183-201.

Flexer, Roberta J. (1987). Extrinsic and Intrinsic Problem-solving Styles of Two Children. The Elementary School Journal, 88(2), 119-133.

Frank, Martha L. (1988). Problem Solving and Mathematical Beliefs. Arithmetic Teacher, 35(5), 32-34.

Garofalo, Joe (1987). Metacognition and School Mathematics. Arithmetic Teacher, 34(9), 22-23.

Hawkins, Jan (1987). The Interpretation of Logo in Practice. In Pea, Roy & Sheingold, Karen (Ed.), Mirrors of Minds: Patterns of Experience in Educational Computing (pp.1-15). Norwood, NJ: Ablex.

Hoff, Benjamin (1983). THE TAO OF POOH. New York, NY: Penguin.

Horner, Charlotte M. & Maddux, Clebourne D. (1985). The Effect of Logo on Attributions Toward Success. In Maddux, Clebourne D. (Ed.), Logo in the Schools (pp. 45-54). New York: The Haworth Press.

Howe, J., O'Shea, T., & Plane, F. (1979). Teaching mathematics through LOGO programming: An evaluation study. DAI Reasearch Paper No. 115.

Hoyles, Celia (1987). Tools for Learning - Insights for the Mathematics Educator from a Logo Programming Environment. For the Learning of Mathematics, 7(2), 32-37.

Krasnor, Linda R., & Mitterer, John O. (1984). LOGO AND THE DEVELOPMENT OF GENERAL PROBLEM-SOLVING SKILLS. The Alberta Journal of Educational Research, 30(2), 133-144.

Kurland, D. Midian, Clement, Catherine, Mawby, Ronald, & Pea, Roy (1987). Mapping the Cognitive Demands of Learning to Program. In Pea, Roy & Sheingold, Karen (Ed.), Mirrors of Minds: Patterns of Experience in Educational Computing (pp. 103-127). Norwood,N.J.: Ablex.

Maddux, Cleborne D. (1989) Logo: Scientific Dedication or Religious Fanaticism in the 1990's? Educational Technology, 29, 18-23.

Mathison, Sandra (1988). Why Triangulate? Educational Researcher, 17(3), 13 -17.

Nesher, Pearla (1987). Towards an Instructional Theory: the Role of Student's Misconceptions. For the Learning of Mathematics, 7(3), 33-39.

Papert, S., Watt, D., diSessa, A., & Weir, S. (1979). Final report of the Brookline LOGO project. Part II: Project summary and data analysis. M.I.T. LOGO Memo # 49.

Papert, Seymour (1980). Mindstorms: Children, Computers and Powerful Ideas. New York: Basic Books.

Papert, Seymour (1984). NEW THEORIES FOR NEW LEARNINGS. School Psychology Review, 13, 422-428.

Papert, Seymour (1987). Computer Criticism vs. Technocratic Thinking. Educational Researcher, 16(1), 22-30.

Pea, Roy D. (1987a). The Aims of Software Criticism: Reply to Professor Papert. Educational Researcher, 16(5), 4-8.

Pea, Roy D., Kurland, D. Midian, & Hawkins, Jan (1987b). Logo and the Development of Thinking Skills. In Pea, Roy & Sheingold, Karen (Ed.), Mirrors of Minds: Patterns of Experience in Educational Computing (pp. 178-197). Norwood,N.J.: Ablex.

Rosen, C. & Rosen, H. (1973). THE LANGUAGE OF PRIMARY SCHOOL CHILDREN. Baltimore, MD: Penquin.

Salomon, Gavriel & Gardner, Howard (1986). The Computer as Educator: Lessons From Television Research. Educational Researcher, 15(1), 13-19.

Stake, Robert (1978). The Case Study Method in Social Inquiry. Educational Researcher, 7(2), 5-8.

Stigler, James W. (1988). The Use of Verbal Explanation in Japanese and American Classrooms. Arithmetic Teacher, 36(2), 27-29.

Vygotsky, L.S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

Walker, Decker F. (1987). Logo Needs Research: A Response to Papert's Paper. Educational Researcher, 16(5), 9-11.

APPENDIX A

ASSIGNMENTS

This Appendix contains the assignment sheets the students received followed by a sample of the computer work pertaining to that project and a sample of the graphic produced (if available).

1. **rectangle tessellation**

LOGO CHALLENGE #1

Tessellating a rectangular shape

Directions:

1) Complete the following procedure in the Logo Editor to make a large border on your screen. You'll be tessellating a rectangle (10 by 20) to cover the area within the large border.

```
TO BORDER
SETBG 0 SETPC 1
PENUP SETPOS [-100 -50]
PENDOWN SETPOS [-100 50]
SETPOS [100 50]
SETPOS [100 -50]
SETPOS [-100 -50]
END
```

2) Construct a procedure that will draw a small rectangle that has a height of 10 turtle steps and a base of 20 turtle steps.

3) Constuct a procedure(s) that will tessellate the area within the border.

Hints:

1. Your rectangles can be arranged in different ways. Just make sure the shapes do not overlap.

2. The REPEAT command can be very useful to repeat a list of directions.
example:

```
REPEAT 5[FD 20 RT 45 FD 10]
```

```
January 24, 1989
Jean    Karen
first project

[[had 1st 2 rows of the tessellation done - had defined
row which gives 1 vertical row of rectangles]]

"row is one we want"

border
row

"okay now
(talks out next instructions)
bk 100 rt 90 fd 20 lt 90 row "
bk 100 rt 90 fd 20 lt 90 row

"get rid of row"

bk 100 rt 90 fd 20 lt 90
setpc 2
bk 100 rt 90 fd 20 lt 90 row

"oh oh what did we do wrong?"
"I did exactly that"
"We went back oh dear"
(realizes the mistake is in the placement of row)

cs
"then we can add in colour and anything"
to rows
border
row   ("leave your row here")
repeat 10[bk 100 rt 90 fd 20 lt 90 ]
end   ("I don't think it will work with so many
brackets." "Let's try it.")

rows
(makes tessellation but too many rows
"oh oh should be repeat 9")
cs
  ed  "rows
"we can also put in colour"

to rows
border
row
repeat 9 [bk 100 rt 90 fd 20 lt 90 row]
```

```
end

(makes the tessellation - ends on top 1 space from
edge)
"We'll make pc the outline colour then fill it in like
a checkerboard."

setbg 1
setpc 1
setpc 3
cs
rows

(makes the tessellation the same way)

"oh well let's set our colour"
"red and black - have to make it black"

paint

(fills all the bkg white)
(laughter) "well it's black and white"

rt 180
setpc 3

paint

(fills the whole screen magenta)

setpc 1
paint

(fills the whole screen white)

fs cs
ss
ed "paint
"you don't have to write the whole thing"

to pt
rt 45
fd 5
fill bk 5
lt 45
end

"let's go to edit and put in colour"
ed "rows

to rows
```

```
setpc 3 setbg 1
border
row
repeat 9[bk 100 rt 90 fd 20 lt 90 row]
end
"let's see what it does"
rows
"what! How come that didn't work?"
"the pc didn't work or anything"
"we changed both pc and bkg"
(makes tessellation as before - no colour)

ed "rows
"see"
(then they changed the order - put bkg the pc)

to rows
setbg 1 setpc 3
border
row
repeat 9 [bk 100 rt 90 fd 20 lt 90 row]
end

rows

"it did it again!"

(makes tessellation as before - no colour)
cs
setbg 1
setpc 3
rows

(same as before)
"edit rows first because we already have colour in"
ed "rows ("get rid of setbg")
to rows
border
row
repeat 9[bk 100 rt 90 fd 20 lt 90 row]
end

cs
setbg 5
setpc 1
rows

(bkg goes blue then makes the tessellation the same as
before)
cs
to rows1 ("this one will have colour")
```

```
border paint
rows
end
"try it"
"we'll have to change pc"

rows1
 (bkg of rectangle turns white and tessellation is drawn
but the lines cannot be seen)
"this is a fascinating picture!"

ed "rows1

to rows1
border paint
setpc 5 rows
end
rows1
(same as last time)

cs
ed "rows1
"okay try 4"

to rows1
  border paint
setpc 4 rows
end
"work this time!!"

rows1
(same as last time)
"We're trying to make a checkerboard
Let's just save it"

Jan. 26, 1989

[They got right into the problem. They were using chec
and border]

chec

J "it's working"

K "we're still trying to work out the problem. Making
the checkerboard is the problem"

ed "chec

J "put in border so we get it at the end"
```

```
to border
border
repeat 5 [ch]
border
end              (added second border)

border

J "this should be pink right"

K "just move 10"

J "but that would be the whole thing
   you need 4 or 5 It's only 10 tall"

K "but we have to get up there to do the black ones
first"

fd 10
pt

J "oh no! that should have been pink"

R "the problem seems to be in that one pink line"

cs chec

fd 15
rt 90
fd 10

fill

K "it did it again
   because of that pink----"

J "maybe instead of a checkerboard we could------"

lt 90
setpc 3
fd 10
fill

J "oh no! not again!"

cs
chec

J "I think we should just leave it with the different
colours and not fill in."
```

K "why did it turn white anyway?"
Did you setbg?
J No

K "We can try this afterwards" (instructions in their book)

J "Let's go for that one there"

```
setpc 3
pt
```

J "oh---"

K "maybe edit it and put it in there"

J "what?"

K "pencolour changing"

```
cs chec
```

K "maybe if we do corners"

J "We shouldn't do border because it gets rid of some of the pink on the edge."

J "edit border and see where it is"

```
ed "border
```

(no change)

K "now edit chec"

J "okay take out the border and put setpos [-100 -50]"

(took out border and put in pu setpos)

```
chec
```

J "if that doesn't work I don't know what will"

K "there!"

J "What colour is the square? It's pink."

```
setpc 3
rt 90 fd 20
lt 180 fd 20
rt 90 fd 10
```

```
bk 10
pt
```

J "oh I see what you're doing " (outlining the rectangle)

J "good It'll take awhile but it'll work"

K "I had a brilliant idea"

J "Let's do all the pink ones first"

K "it'll be kind of awkward"

(talking instructions together)

```
setpc 0
rt 90
fd 20
bk 20
lt 90
fd 10
bk 10
pt
setpc 3 rt 90 fd 20 bk 20 lt 90 fd 10 bk 10 pt
```

(used control r to repeat the line and just change the pencolour They did this 8 times.)

[it worked every time until the corner when the black filled the screen]

J "we have to make this into a procedure"

K "call it another name - How about colours?"

J "We could call it check with a k "

(Karen uses this suggestion)

```
to check
chec
```

J "we should use a repeat"

K "no because it would do it all one colour (repeat the same thing)"

J "no just repeat how many times----"

K "We might as well do it this way because it's easy to use control R"

J "okay"

(they used Karen's plan this time)

setpc 0 rt 90 fd 20 bk 20 lt 90 fd 10 bk 10 pt

J ""What colour is the border? Black or pink - even if it is black we can change it."

J "how many times do I do this?"

K "We'll just do it as many times as we think we'll need."

(used control r again and changed the pc 9 times)

end

R "that's smart you decided to use a procedure."

K "major discovery"
"We have a hundred squares so we have to do it 100 times."

J "are you sure there are 10 across?"

K "no but---(she starts counting)

cs check

K "I'm going to see how far this gets us."

J "Why's it doing that? It's not going to do it because we didn't tell it to go back."

K "we're checking to see where it goes"

T "What would happen if we took the border out?"

Girls "we did and changed------oh"

(fills in black)

T "I think it's the border that does that"
"Let's take the border out"

R "let's see if it does do it 10 times"

cs
ed "chec

```
K "take out this border"

to chec
repeat 5 [ch]
setpos [-100 -50]
end

cs
chec

J "it does it in the middle of nowhere"

K "We have to put setpos"

J "it goes to the corner because we didn't setpos at
the beginning and at the end"

ed "chec

to chec
pu setpos [ch]
repeat 5 [ch]
pu setpos [-100 -50] pd
end

cs check

check

stopped in check

cs
check
stopped in pt
cs
ed "check
(put in chec border)
chec
border
setpc 0 rt 90 fd 20 bk 20 lt 90 fd 10 bk 10 pt
setpc 3 rt 90 fd 20 bk 20 lt 90 fd 10 bk 10 pt
(this repeats so there are 9 altogether)
end

cs check

stopped in rec (colour goes over the space at the end
of the row)

R "where are the instructions for changing the border of
each rectangle?"
```

J "we do that because the outline has to be the same."

R "yes but where is that in your editing - maybe you did something wrong there."

K "no because that's what we did"

R "it worked when you did it individually so Kelly's right it should work in the procedure so maybe you made a mistake in there."

T "I'll tell ycu something about the fill command. The outline has to be the same as the fill colour."

K & J "we did that!"

R (insistant) "let's look back at the procedure."

K " we need the border in there maybe that's it"
(she calls out the lines while the researcher tries to slow her down)

R "but is that right?"

K (insistant that it's right because that's what they had done)

R "wait isn't it the bottom that's black or is it pink?"

J "no it's pink - oh we got it backwards!"

R "I knew it was probably some little thing in there."

J "we have to change all the numbers."

[changed all the 0's to 3's and 3's to 0's]

(researcher shows them the up and down arrows)

Feb. 9, 1989

They have been working on Logo challenge #2.

They came at the beginning of the period to tell me "we finished the checkerboard"

They did the checkerboard to show me. (made rectangles and then coloured them in but the second time it put coloured rectangles in 1 at a time)

2. **semitessellation**

LOGO CHALLENGE #2
TESSELLATING TWO POLYGONS

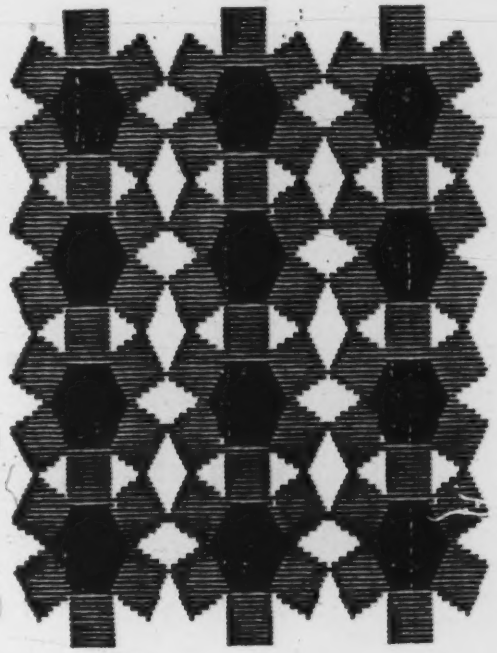
Directions:
Use two of your polygons to construct a tessellation.

Develop separate move procedures to move the turtle to different positions.

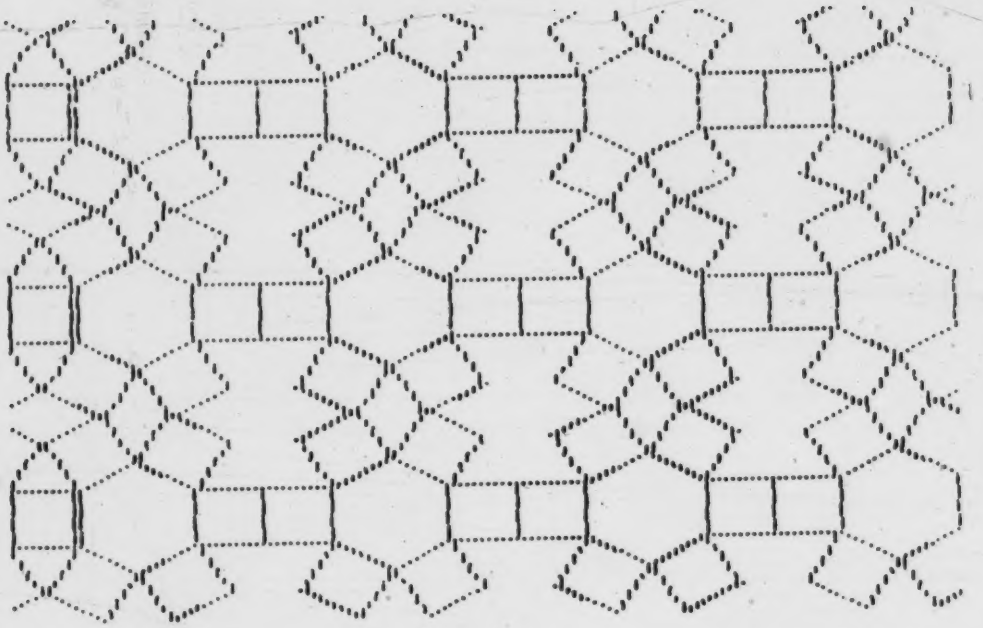
Study the display in the hallway for possible ideas.

example of a partial solution:

```
TO TESS
SETUP1
PATTERN
SETUP1
BACK 60
PATTERN
SETUP1 BACK 120
PATTERN
FULLSCREEN
END

TO PATTERN
REPEAT 4 [SHAPE MOVE1]
END

TO SQUARE
PENDOWN SETPC 5
REPEAT 4 [FD 20 RT 360/4]
PAINT
END

TO HEXAGON
SETPC 1
REPEAT 6 [FD 20 RT 360/6]
PAINT
END

TO MOVE1
SETH 90 PU FD 55 SETH 0 PD
END

TO PAINT
RT 45 FD 5 FILL
BK 5 LT 45
END

TO SETUP1
PU SETPOS [-100 70]
END
```



Assignment #2 Simon and Ross
Tessellation using Two Polygons
Feb. 13, 1989



Simon and Ross

Feb 10,1989

(moon is a semi tessellation of hexagons surrounded by 6 squares)

```
?FD 10      (line)
?CS
?SETPC 5
?FD 10     (blue line)
?CS
?FD 120        (longer blue line)
?CS

?MOON          (1 row of tessellation)
?FS
?SS
?FD 20         (moving turtle for next row)
?LT 90
?RT 18
?FD 20
?RT 30
?PU
?FD 25
?FD 15
?MOON        (started in the middle - overlaps)
?CS
?ED

TO D
REPEAT 9999[CS]
END

?SS
?D         (turtle at home and clears over and over)

?CS
?MOON     (same row moved down a bit)
?DOO
?CS

?COOL          (1 shape)
?CS
?ED          (deleted to d)

TO X
RODDY COOL
REPEAT 3[COOL
```

[[This group didn't use names that were connected to the shape]]

```
?SS
?X      (1 shape - rotated and 1 more shape that
overlaps)

STOPPED
```

[[They stopped it and then went to individual instructions to find the correct place for the turtle - then go back to edit]]

[Simon uses scrap paper to figure out the angle]

```
?CS
?RODDY
?COOL

Ro "Write this down"

?LT 90
?LT 30
?FD 20
?LT 30
?FD 20
?LT 90
?BK 20
?PU
?FD 25
?LT 90
?PD
?COOL
?ED

TO X
RODDY COOL
REPEAT 3[COOL LT 120 FD 20 LT 30 FD 20 LT 90 BK 20 RT 90 PU FD 20
LT 90 PD]
END

?COOL
?X        (several shapes with rotated overlapping shapes)

?ED

TO X      (took out cool in 2nd row)
RODDY
REPEAT 4[COOL LT 120 FD 20 LT 30 FD 20 LT 90 BK 20 RT 90 PU FD 20
LT 90 PD]
END
```

```
?X      (1 row and turtle moves to middle of the 1st
hexagon)

?ED

TO X      (no change)

RODDY
REPEAT 4[COOL LT 120 FD 20 LT 30 FD 20 LT 90 BK 20 RT 90 PU FD 20
LT 90 PD]
END

?SS
?ED

?CS
?X
STOPPED
?CS
?HT
?X      (1 row)
?FS
?SF
ST    (turtle in the middle of the 1st hexagon)

[[they are trying to find the correct position for the
turtle 1 command at a time]]

?PU
?FD 20
?FD 5
?RT 30
?LT 30
?FD 5
?RT 25
?RT 25
?LT 5
?FD 20
?LT 30
?RT 10
?FD 25
?FD 5 LT 90
?LT 90
?FD 0
?FD 10
?RT 90
?X      (1 row over the first beginning in the middle)

?ED     (took out roddy at the beginning)

?RODDY
```

```
?X          (1  row)

[[1 command at a time to figure out the correct
positioning]]

Ro "Write this down!"

?PU
?FD 20
?FD 5
?RT 20
?LT 20
?FD 5
?RT 20
?FD 20
?LT 25
?FD 30
?LT 90
?FD 20
?FD 20
?FD 10
?RT 90
?X        (1 shape, pu and then the rest of the row above
the 1st)

?CS
?ED

?RODD6
?RODDY
?X         (1 row)
?PU
?FD 30
?RT 20
?FD 20
?LT 20
?FD 30
?LT 90
?FD 20
?RT 90
?PD
?X      (2nd row - almost touches)
?CS
?RODDY  (try it again)
?X
?PU
?FD 30
?RT 20
?FD 20
?LT 20
?FD 30
```

```
?BK 5
?LT 90
?FD 20
?RT 90
?PD
?X        (this time the 2 rows just touch)

?PU
?FD 30    (trying a 3rd row)
?RT 20
?FD 20
?LT 20
?FD 25
?LT 90
?FD 25
?RT 90
?X        (1st one pu then rest of the row was drawn)
?CS
?ED

TO X
RODDY
REPEAT 4[COOL LT 120 FD 20 LT 30 FD 20 LT 90 BK 20 RT 90 PU FD 20
LT 90 PD]
END

TO Z
REPEAT 3[X PU FD 30 RT 20 FD 20 LT 20 FD 25 LT 90 FD 25 RT 90 PD
X]
END

?SS
?Z      (began in home position)
?CS
?RODDY
?Z      (2 rows - 3rd row overlaps 2nd)
?CS
?ED     (took out last x)

TO Z
REPEAT 3[X PU FD 30 RT 20 FD 20 LT 20 FD 25 LT 90 FD 25 RT 90 PD]
END

?SS
?Z      (3 rows tessellated)
?CS
?RODDY
?Z
```

feb 13, 1989

Ro "What's our big thing? What did we call it again?

Ro "What did we save the design on? Was it x?"

```
?CS
?X      (1 shape)
?CS
?SETPC 5
?RODDY
?X          (1 row but pauses between shapes)
```

S "At least it's good our computer thinks. It's finished - z was our design)

```
?CS
?RODDY
?Z      (3 rows but it pauses after each shape)
?FS
?SS
?CS
```

T "Have you saved that as a picture?" (explained about SAVE, SAVEPIC AND ERASE)

```
?HT
?RODDY
?Z
?HT
?SAVEPIC "RS
?SAVEPIC "RR    (teacher did it)
```

[They went to print the picture]

```
?RODDY
?BK 5
?CS
?RODDY BK 5
?HT
?Z          (design fits on the screen better)
```

[trying to move the picture down so it fits right on the page]

```
?FS
?TO KORI      (a setup procedure )
>RODDY BK 5
>END
?CS
?ST
?KORI
```

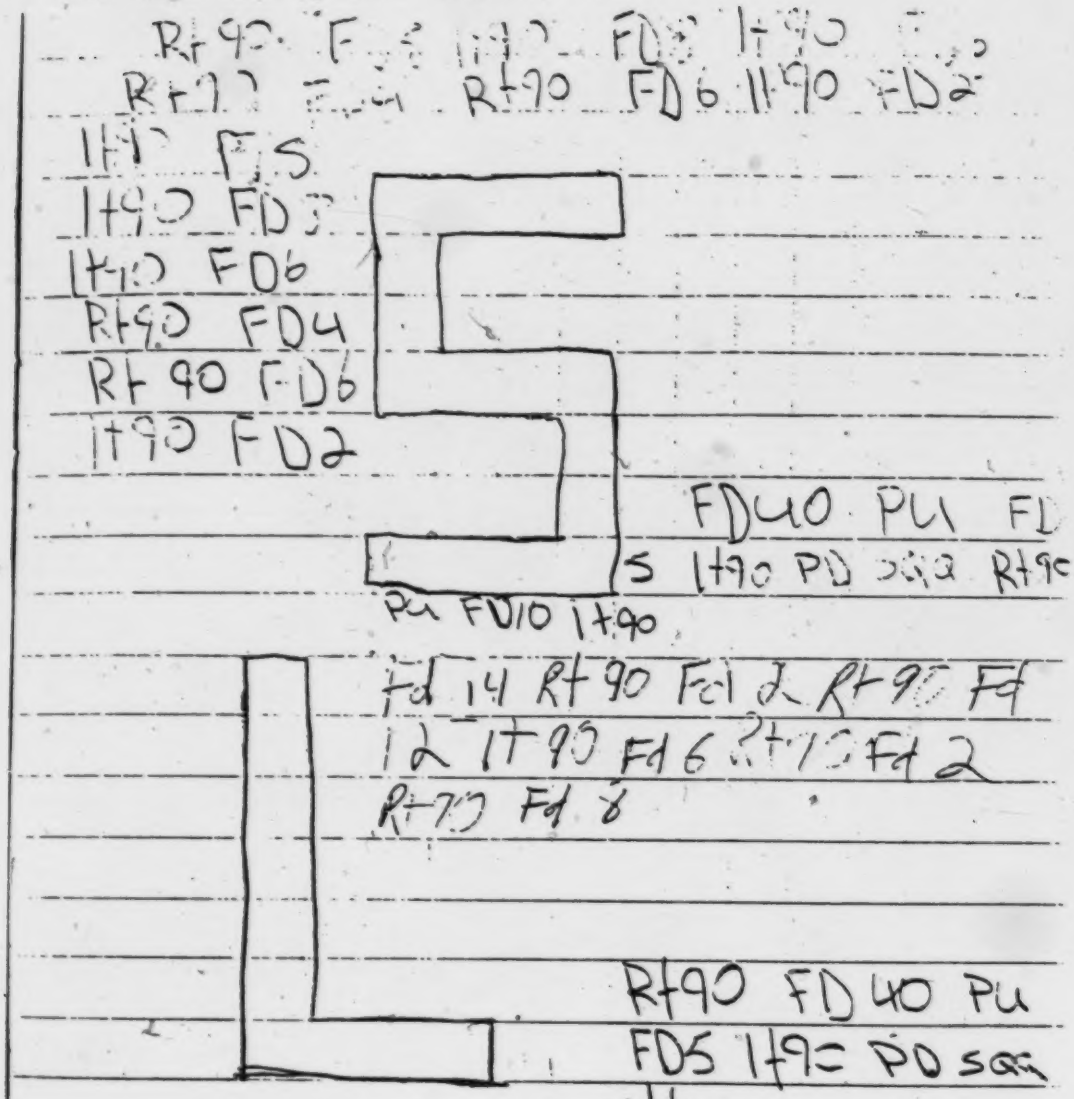
3. **letters using variables**

LOGO ASSIGNMENT #3

Make letters using a variable. An example is given.

```
TO  L  :SIZE
FD  10  *:SIZE  RT  90
FD  2  *:SIZE  RT  90
FD  8  *:SIZE  LT  90
FD  6  *:SIZE  RT  90
FD  2  *:SIZE  RT  90
FD  8  *:SIZE  RT  90
END

TO  PAINT
RT 45  FD  2  FILL  BK  2  LT  45
END
```

A Page from Simon's computer book.



206

Simon Ross

Feb 15, 1989

(they are using the procedure the teacher gave them for variables)

[Ross is fooling around. Simon wants to do something but Ross is just putting down anything.]

(Simon takes over the keyboard)

```
TO L :SIZE
```

(Ross keeps trying to press the keys. Simon is becoming upset)

```
FD 10 * :SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE RT 90
FD 6 *: SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE RT 90
END

?SETPC 5
?L
?L 2        (cross)
?CS
?L 90       (lines - wraparound)
?CS
?L 99999
?L 999
?CS
?L 1
CS
?L 4        (backwards L)
```

Ro "It's not right"

R "Perhaps you did something wrong. How are you going to find out?"

S "Go to the editor"

?ED

(S talks through each instruction)

```
TO L :SIZE
```

```
FD 10 * :SIZE RT 90
FD 2 *: SIZE RT 90

Ro  "oh  lt  not  rt"

FD 8 * :SIZE LT 90
FD 6 *: SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE RT 90
END

?S
?CS
?L 2
?CS
?LT 9999   (intersecting  lines)
?CS
?L 999
?CS
?L 8

S  "Good  size.  Let's  do  the  paint  instruction  because  it
will  fill  it  in."

?CS
?L10
?CS
?L 30    (too  big)
?CS
?L 20   (too  big)
?CS
?L 15

?PU
?SS
?PU
?BK 80
?LT 90
?FD 50
?RT 90
?PD
?L 30        (too  big)
?CS
?L 20       (too  big)
?CS
?L 15
Ro  "See  it's  13"
?CS
?L 14
?CS
?L 13
```

```
?CS
?L12      (good size)
?ED


TO L :SIZE
FD 10 * :SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE LT 90
FD 6 *: SIZE RT 90
FD 2 *: SIZE RT 90
FD 8 * :SIZE RT 90
END

TO PAINT          (Simon dictates the instructions)
RT 45 FD 2 FILL BK 2 LT 45
END

?SS
?PAINT
?CS
?L 12 PAINT        (blue L)
?CS

S "If you can get another L going this way it'll be a
square"

?L 12 SETPC 3 PAINT      (pink L)

(making a small square for a period)

[[Going step by step rather than a procedure]]

?CS
?ED

?FD 4
?RT 90
?FD 4
?RT 90
?FD 4
?RT 90
?FD 4
?RT 90
?BK 2
?RT 90
?FD 6
?LT 90      (making a square within a square)
?FD 6
?LT 90
?FD 6
```

```
?LT 90
?FD 6
?LT 10
?BK 2
?HT
?CS
?FD 10
?RT 90
?FD 10 RT 90 FD 10
?RT 90
?FD 10
?RT 90
?BK 2
?ST
?HT
?RT 90
?FD 15
?LT 90
?FD 15
?LT 90
?FD 15
?FD 5
?LT 90
?FD 15
?CS
?RT 90
?FD 10
?CS
?HT
?FD 10 RT 90 FD 10 RT 90 FD 10 RT 90 FD 10
?RT 90
?ST
?BK 2
?RT 90
?FD 15
?LT 90
?FD 15
?LT 90
?FD 15
?HT
FD 2
?FD 1
?LT 90
?FD 15
?LT 90
?FD 2
?CS
```

R "What are you doing now? Have you tried the L in different sizes at the same time?"

```
[*(they tried experimenting with a) sizes b) rotating]

?L 12
?L 1
?CS
?RT 90
?L 1
?L 2 L 3 L 4 L 5 L 6 L 7 L 8 L 9 L 10 L 11 L 12
(L's lying down)

S "Look at that - it's cool"

?CS
?ST

(try again with the turtle at home)

?L 1 L 2 L 3 L 4 L 5 L 6 L 7 L 8 L 9 L 10 L 11 L 12 (L gets
bigger each time and looks 3 dimensional)

?CS
?L 3
?CS
?L 10
?CS
? L 5
?RTCS
?RT 30
?L 5 RT 30 L 5 RT 30 L 5 RT 30 L 5 RT 30 L 5 (design with
L rotating 30 degrees each time)

? CS
?REPEAT 30[RT 30 L5]

S "30 is too many"

STOP
?CS
?L 12
?CS
?REPEAT 20[RT 30 L 12 (large design)

S "still too many - maybe 15"

?FS
?CS
?SAVE COOL
```

4. **monogram using variables**

LOGO CHALLENGE #4

Personal monogram

Directions: Use your graph paper to design letters to represent the initials of your name. Try to use a variable in your procedures so that you can control the size of your crest.

The following printouts demonstrate procedures that were defined to make a personal crest for a student named Trevor Lee.
Good luck, try your best.

```
TO INITIALS :S
PENDOWN
T :S
PERIOD :S
MOVE1 :S
L :S
PERIOD :S
BORDER :S
BORDER2 :S
END
```

```
TO T:S
FD 12 * :S RT 90
FD 6 * :S LT 90
FD 2 * :S LT 90
FD 14 * :S LT 90
FD 2 * :S LT 90
FD 6 * :S RT 90
FD 12 *:S LT 90
FD 2 * :S
SETH 0
PAINTLEFT
END
```

```
TO MOVE1 :S
PENUP
RT 90
FD 4 *:S LT 90 PD
END
```

```
TO L :S
FD 14 * :S RT 90
FD 2 * :S LT 90
FD 12 * : LT 90
FD 6 * :S RT 90
FD 2 * :S RT 90
FD 8 * :S RT 90
RT 90 FD 6 * :S LT 90
PAINTRIGHT
END
```

```
TO BORDER :S
RT 90 PU FD 4 * :S LT 90
PU LT 90
FD 35 * :S
RT 90 BK 5 * :S PD
FD 25 *:S RT 90
FD 35 *:S RT 90
FD 25 *:S RT 90
FD 35 *:S RT 90
END
```

```
TO BORDER2 :S
LT 90 PU FD 2 *:S SETH 0
PD
FD 27 *:S RT 90
FD 39 *:S
RT 90
FD 29 *:S
RT 90
FD 39 *:S
RT 90 *:S END
```

```
TO  PAINTLEFT
LT 45 FD 1 FILL BK 1 RT 45
END

TO  PAINTRIGHT
RT  45  FD  1  FILL  BK  1  LT  45
END

TO  PERIOD  :S
MOVE1  :S
REPEAT  4 [FD  1  *:S  RT  90]
PAINTRIGHT
END
```

Anna and Susan's Project - Assignment #4

Susan and Anna

Feb. 20, 1989

(observation)

Logo Challenge #4 - Monogram

They are putting the variable in the letter procedures they had worked out and the procedures work.

They try to fix the N. They go through the procedure line by line.

They ended by having the word SEAN.

Feb. 21, 1989

```
?SS
?D      (flower made of hexagons)

?CS
?Z      (Z shape made out of 5 squares)

?CS
?PLUS   (makes a plus sign out of 5 squares)

?CS
?CHAIR  (looks like a desk out of 5 squares)

?CS
?W      (looks like 2 rows of stairs)

?CS
?ED MOVE
```

[erased it]

```
?S
?MUV    (moves to the top left)

? A 2   (makes A in that position)

?CS
?PERSON      (makes SEAN)

?CS
?MUV
?ST   *  (check on the position before beginning)

?A 2     (makes A)
```

```
?SPACE3   (ends up farther left)

?ED PERSON

* [ checked to make sure that was the command they used
in making the previous word]

?CS
?MUV
?A 2
?SPACE4  (turtle moves to the right of A)

?L 2
?PU
?RT 90 FD 45
?LT 90

TO SPACE5
>PU RT 90
>FD 45 LT 90
>PD
>END
?PD

?HI 2     (makes H in the next space)

?PE HI 2

?ST
? I 2
I DON'T KNOW HOW TO I

?I     (nothing there)

?TO I
?ED I

TO I
FD 5 * :SI
RT 90 FD 25 * :SI
RT 90 FD 5 * :SI
RT 90 FD 10 * :SI
LT 90 FD 15 * :SI
LT 90 FD 10 * :SI
RT 90 FD 5 * :SI
RT 90 FD 25 * :SI
RT 90 FD 5 * :SI
RT 90 FD 10 * :SI
LT 90 FD 15 * :SI
LT 90 FD 10 * :SI
RT 90 HT
```

```
END

?SS
?I2
SI  HAS  NO  VALUE  IN  i

?ED I
?
TO I * :SI        (put  *:si  in  this  line)

FD 5 * :SI
RT 90 FD 25 * :SI
RT 90 FD 5 * :SI
RT 90 FD 10 * :SI
LT 90 FD 15 * :SI
LT 90 FD 10 * :SI
RT 90 FD 5 * :SI
RT 90 FD 25 * :SI
RT 90 FD 5 * :SI
RT 90 FD 10 * :SI
LT 90 FD 15 * :SI
LT 90 FD 10 * :SI
RT 90 HT
END

?I 2
?ST

?ED SPACE
TO SPACE 5
PU RT 90
FD 45 LT 90
FD 40 PD      (added  this  line)
END

?SS
?PU
?FD 40
?I 2
?ST
?PD
?I 2     (I  with  long  top  and  bottom  lines)

?ST
?HT
?TO SPACE6
>ST PU
>RT 90 FD 55
>LT 90 BK 30
>PD
>END
```

* [In planning the spaces Anna used her finger to estimate the distance and then checked with Susan]

```
?SPACE6
?ED SPACE 6

TO SPACE6
ST PU
RT 90 FD 55
LT 90 BK 40
PD
END
?BK 10
?PE FD 10
?PU
?BK 10
?PU
?S 2
YOU  DON'T  SAY  WHAT  TO  DO  WITH 2

?SEANS 2

?ED SPACE6


TO SPACE6
ST PU
RT 90 FD 55
LT 90 BK 40
FD 50 RT 90 FD 40 LT 90 PD    (added  this  line)
END
?PU

?FD 50
?RT 90 FD 4 LT 90
```

* [[they seem to be checking out line by line what the space procedure will do after they made it. They are doing it with the pen up. This is the 2nd or 3rd time they have done this today]]

```
?PD
?SEANS 2     (makes  a  S)
```

* [[Again they are determining the commands for a space procedure and then defining it]]

```
?PU
?BK 50
?RT 90 FD 5
?LT 90
```

```
?SPACES6
?TO SPACE7
>PU
>BK 50 RT 90
>FD 5
>LT 90
>PD
>END

?PD
?A 2          (makes the last A)

?HT
?CS
?ST       [[they couldn't decide where the turtle was]]

?PU FD 50
?LT 90 FD 90
?FD 30
?RT 90

?TO MUV1
>PU FD 50 LT 90 FD 90
>FD 30 RT 90 PD
>END

?CS
?TO ALISA
>MUV1 A 2
>SPACE 4 L 2
>SPACE5 I 2
>SPACE 6 S 2
>SPACE 7 A 2
>HT
>END

[[making 1 procedure from all the procedures they made.
It does not seem logical that they need so many space
procedures]]

?ALISA      (stops at the S)

?ED ALISA

TO ALISA
MUV1 A 2
SPACE 4 L 2
SPACE5 I 2
SPACE 6 SEANS 2       (put SEANS instead of S)
SPACE 7 A 2
HT
```

END

?CS
?ALISA (makes ALISA on the top half of the screen)

A &S "Wow!"

?CS
?ALISA (same)

?CS
?SAVE LISAS

?ALISA
[[just checking it out]]

Feb. 22, 1989

(observation)

They began by trying R as we had talked about in the interview.

* [turns book]

S "Except these ones might not be right"

* [she underlines them]

The lines were short so they put in 1.41.

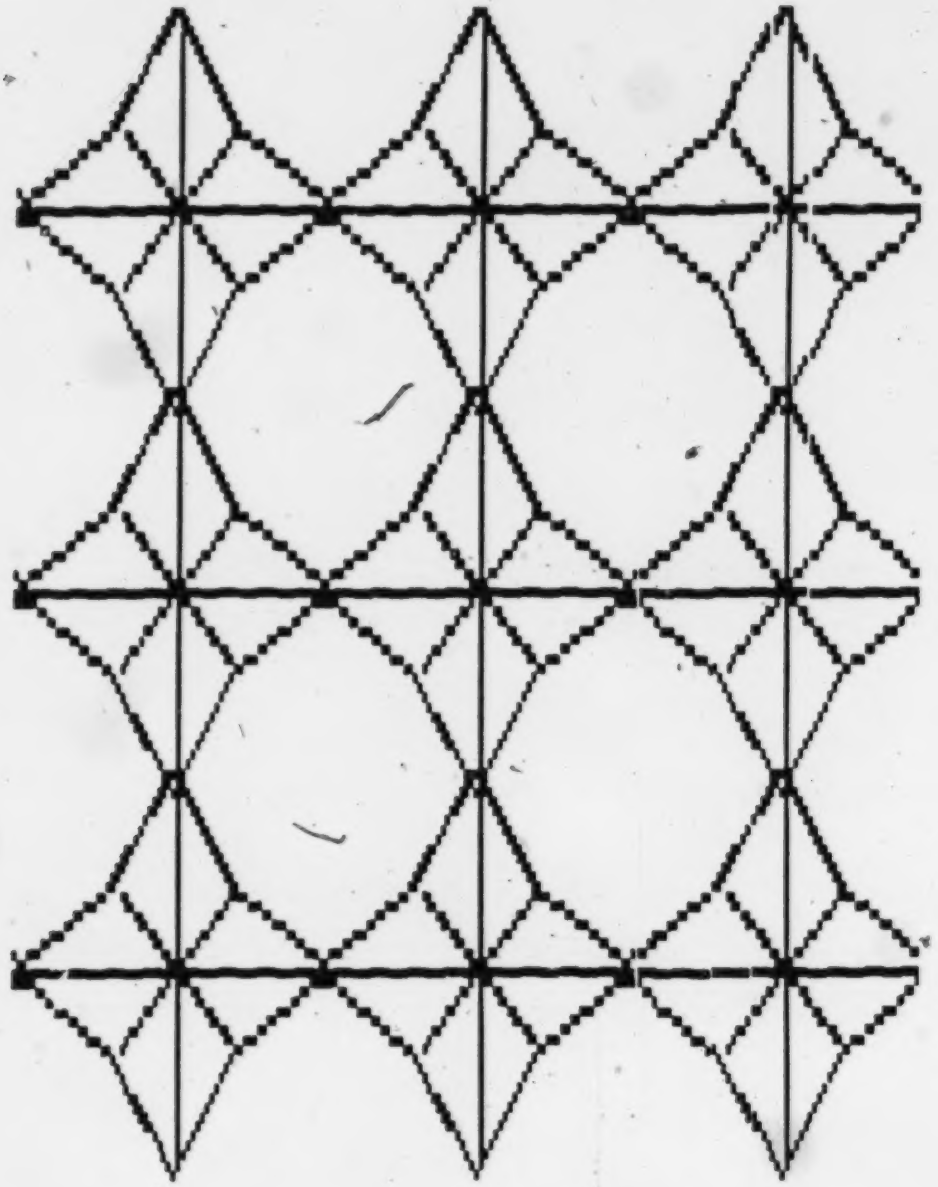
They had SAR and were pointing and measuring on the screen.

Later they were trying to space it so they can put SARA and ALISA on the screen at the same time.

5. **design**

This assignment was explained orally. Students were asked to make any design and use a variable.

Susan and Anna's Design



Anna and Susan
Feb 27, 1989

See Appendix B.

Feb. 28, 1989

(observation)

They went directly to checking the procedure we worked on yesterday.

They made adjustments to the angles turned and the lengths of lines to get the outside right.

We worked together on this but I only asked 2 questions at the beginning and then they carried on in the same fashion.

R "How much do we have to turn the turtle?"

"Is there another place we need to fix?"

S "145 - a real number"

By 9:30 the lines don't quite match up so they are adjusting lines in CROSS to meet.

They do half by themselves but they are getting anxious. [:it doesn't work!" "We did that"]

[[They are looking at the screen rather than the editor]]

R "Let's go through line by line"

* [Talk it through - S "oh that should be 5.5 as well"]

Mar 2, 1989

```
?FCROSS4
?ST
?REPEAT 4 [FCROSS]
?REPEAT 4 [FCROSS 4]    (made 4 fcrosses which overlapped)

?CS
?FCROSS
?FCROSS 4
?ST
?LT 45
```

```
?RT 10
?FCROSS 4   (another cross touching points at the top)

?FS
?FCROSS 4     (a third cross touching at the points)

* [multiply to figure out the number of spaces]

S shakes her head "it's not in the right place"

* [begin over again]

[making a second row]
[made a third row]

?PE FCROSS
?PE FCROSS 4
?FS
?PU
?CS
?SS

?TO SETUP
>PU
>LT 90 FD 80 RT 90 BK 70 PD
>END

?SETUP (takes the turtle to the bottom about one third
of the way across the screen)

?ED SETUP

TO SETUP
PU
LT 90 FD 120 RT 90 BK 100 PD
END
(changed bk to 100)

?CS
?SETUP       (bottom left corner)
* [tried and adjusted in order to reach the corner]

?FS

[made first row]

?LT 90
?REPEAT 3 [FCROSS 4 LT 35[]
?PD REPEAT [FCROSS 4 LT 35]          (makes second row that
touches)
```

```
?FS
?ST
?RT 90
?PU
?FD 80
?LT 90
?PDREPEAT 3 [FCROSS 4 LT 35]
?PD REPEAT 3 [FCROSS 4 LT 35]      ((makes third row)

?ED

*[[When the procedure works they try to guess and adjust
the set up in order to get it in the correct position]]

TO SETUP
PU
LT 90 FD 100 RT 90 BK 100 PD
END
(changed fd to 100 from 120)

?SS
?CS
?HOME
?ST
?CS
?SETUP   (moves farther down the screen)

?FS
?CS
?SS
?TO FF
>SETUP
>REPEAT 3 [REPEAT 3[FCROSS 4 LT 35] PU RT 90 FD 80 LT 90 PD] >END

?FF    (makes 3 rows of fcross)

?ED SETUP

TO SETUP
PU
LT 90 FD 90 RT 90 BK 100 PD
END
(changed fd 100 to 90)

?CS
?FF      (3 rows of fcross)

?ED

TO SETUP
PU
```

```
LT 90 FD 90 RT 90 BK 80 PD
END
(changed bk 100 to 80)

?FF     (3 rows but further up)

S "It should have been more (a higher number). You went
the wrong way."

TO SETUP
PU
LT 90 FD 90 RT 90 BK 120 PD
END
(changed bk 80 to 120)

* [They continue to guess - check - and adjust]]

?CS
?FF       (3 rows with just a bit missing at the bottom)

?CS
?ED

TO SETUP
PU
LT 90 FD 90 RT 90 BK 125 PD
END
(changed bk 120 to 125)

* [try and adjust]

?SS
?FF     (stopped in mid procedure)

?FF      (a bit more was missing from the bottom)

TO SETUP
PU
LT 90 FD 90 RT 90 BK 122 PD
END
(changed bk 125 to 122)

?SS
?FS
?FF       (stopped - a bit missing)
?ED SETUP

TO SETUP
PU
LT 90 FD 90 RT 90 BK 121 PD
END
```

```
(changed  to  121)

?CS
?FS
?FF          (better)

?ED SETUP

TO SETUP
PU
LT 90 FD 90 RT 90 BK 118 PD
END
(changed  to  118)

?CS
?ST
?FF       (almost)

?ED SETUP

TO SETUP
PU
LT 90 FD 90 RT 90 BK 116 PD
END
(changed  to  116)

?SS
?CS
?FS
?FF         (good  spacing)

?ED SETUP

TO SETUP
PU
LT 90 FD 90 RT 90 BK 115 PD
END

?FS
?FF         (a  bit  missing  from the  top)

*[[They  settled  on  15  because  that  is  a  normal  number]]

?SS
?SAVE PIC
?SAVE FF
```

6. **dividing rectangles**

LOGO CHALLENGE #6

DIRECTIONS:
1) Check Logo's memory (POTS) to see if you have the necessary tools to do your work. You should have the following procedures.
TO REC :COLOR
TO PAINTR
TO SETUP
TO PAINTL

2) Check to see that the procedures are working properly. Notice that the REC procedure has a variable: color. This variable allows you to input a number to change the pencolor.

3) Use the REC procedure to design a rectangle on your screen. Divide the rectangle into two equal parts. Use the painting procedures to color in one of those equal parts. You can solve the problem in different ways.

4) Save your different solutions onto your disk by using the SAVEPIC command.

5) Divide the rectangle into 3 equal parts. Color each part with a different color. SAVEPIC your solutions.

6) Use your REC procedure to draw a rectangle. How many different ways can you divide the rectangle into four equal parts? Save your solutions.

Alan and Mike

March 6, 1989

(observation)

Logo Challenge #6

They began work on the assignment but were not doing much.

T reminded them to work on the assignment rather than discuss recess and after school.

The teacher helps A get solution #1. [A gave the numbers to move]

They continue with solution #2. M asks A for the numbers to use and although A talks non stop about other things, he does contribute to the job.

They have a solution #2 after experimenting with the colour.

They are beginning to try to solve the problem a different way.

March 8, 1989

*[Mike begins immediately loading the solutions from last time]

```
?CS
?SOLUTION1
I DON'T KNOW HOW TO SOLUTION1
?LOADPIC SOLUTION1      (rectangle half pink)
?CS
? LOADPIC SOLUTION2     (rectangle bottom half blue)

? LOADPIC SOL3          (rectangle one quarter pink)

?HT
?ST
```

[M asks A about the colour but A makes a comment about there being 2 turtles]

```
?FD 50      (part of line turns blue)

?SETPC 3
```

?BK 50 (turns pink again)

A "They should have all the colours - not 5 lousy colours!"

?FD 80
?BK 30
?SETPC 5 PAINTL (covering everything blue)

M "Ah!"

A "How dare it do that! It's so stupid!"
"The turtle was in there"

R "I know but what else do you have to remember about PAINT"
(pause)
"You have to have the outside be the same colour."

STOPPED! IN PAINTL

?CS
?LOADPIC SOL3
?FD 20
?SETPC 3
?BK 20 FD 20
?SETPC 5
?FD 90 (line is blue)

M "How much would that be?"

A suggests numbers

?LT 90 FD 100
?FD 20
?LT 90 FD 80
?LT 90 FD 120
?LT 90 FD 40
?LT 90
?PAINTL (rectangle they outlined is blue)

M "Let's make each one a different colour"

A "That won't work"

M "We could make 1 green"

[[working on making 4 rectangles of different colours but they have some trouble later with colours bleeding]]

?RT 90

```
?BK 40
?SETPC 2
?FD 80
?RT 90 FD 120
?RT90 FD 80
?RT 90 FD 120
?RD 90 FD 40 RT 90
?PAINTR     (1 rectangle is green)

M "This is neat"

A "We have a choice now"

M "No we don't"

?LT 90
?LT 180
?FD 40
?SETPC 4
?LT 90
?LT 18
?FD 120
?LT 90 FD 80 LT 90 FD 120

A "Right on top of the old turtle"

?FD 80
(wrong direction)

[[This is where they start having difficulty with the
colour because they didn't stay within the boundaries]]

?BK 80
?LT 90 FD 80
?BK 40
?LT N90
I DON'T KNOW HOW TO N90
?LT 90
?PAINTL      (last rectangle is orange)

M "Let's save it"

A "Not yet - we gone this far it may as well look
good"

?RT 90
?BK 40

A "Stupid bleeding thing!"

?RT 90
```

```
?SETPC 1
?FD 180

M "Now I've gone too far"

?PE 180
YOU DON'T SAY WHAT TO DO WITH 180
?PE 180
YOU DON'T SAY WHAT TO DO WITH 180
?PE BK 180
?FD 80     (doesn't seem to be a white line)

?BK 80
?SETPC 1
?PD
?FD 120
?LT 90

A "Try 180"

?FD 180     (goes all the way)

A "What!!"

?PE BK20
I DON'T KNOW HOW TO BK20

?PE BK 20

*[ used textscreen to see previous commands]

?LT 90

A "This is so stupid. It can't do anything without
bleeding."

?FD 240

A "It didn't bleed"

M "yeah but it didn't make a line"

?BK 240
? RT 90 FD1
* [[It seems that Mike thought he might not be able to
see the line because it was on top of the previous one
so he moves the turtle 1 space and then draws it.
Different way of checking.]]

A "I think we should just get rid of it"
```

```
?PD
?LT 90 FD 240  (white line 1 space out)

A "That's odd it's a space away"

?LT 90
?FD 1860
?PE BK 1860
?PD FD 160
? LT 90 FD 80
?FD 20

A "The computer gets a kick out of that"

?FD 10
?FD 10
?SAVEPIC SOL4

?CS
?LOADPIC SOL3
?LOADPIC SOL4

*[ They check after it's been saved to make sure (or
they think they are)]

(the sound disappears)

R "What other ways could you use to solve the problem?"

[They suggested the diagonal]

*  [M used guess - check - adjust]

*  [A gave suggestions. A thought of using decimals]

*  [[Mike really uses the guess - check - adjust method
well. He started right away when working on the
diagonal]]

?CS
?SETUP
?REC 1
?RT 45
?FD 240      (not to corner)

?CS
?SETUP
?REC
?RT60
?FD 240    (closer)
```

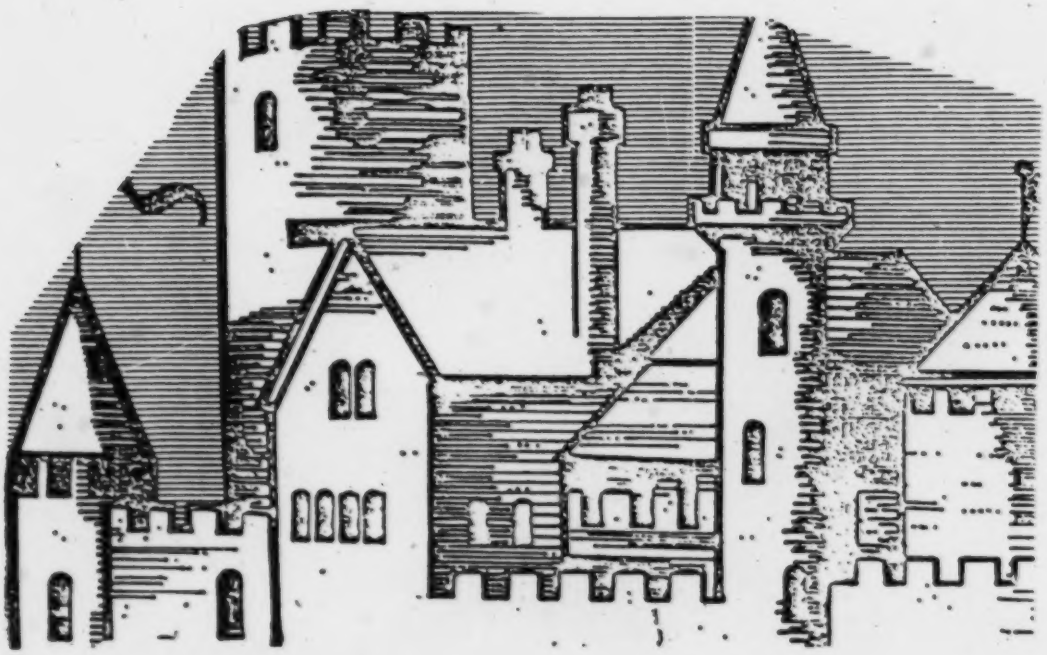
```
CS
?SETUP
?RT55    (closer)

?FD 240
?FD 30
CS
?SETUP REC  1 RT 57 FD 240     (quite  close)

?FD 30
?FD 10    (almost)

?FD 10

?CS
SETUP REC 1 RT 56 FD 250
(zeroing   in  on  the position)

CS
?FD 20
?FD 10
?FD 10
?HT
?CS SETUP REC 1 RT 56.3
?FD 250
?FD 30
?FD 20
?PE 10
YOU DON'T SAY WHAT TO DO WITH 10
?PE BK 10
?ST       *(to  check  position)

[They  have decided  to  make  another  diagonal line]

?LT 120
?RT 20
?RT 20
?RT 20
?BK 180

*[  R  reminded  them  of  SETH]

R  "do  you  remember  about  SETH?"

M  "No"

explained

*[[They  used  SETH  0  several  times.  There  was  some
followup]]
```

```
?SETH
NOT ENOUGHT INPUTS TO SETH
?SETH 0
?PU LT 990CS
I DON'T KNOW  HOW TO 90CS
?CS
?SETUP REC 1
?RT 56.3 FD 280
?HT
?FD 10
?SETH 0
?ST
?BK 80
?BK 80        (turtle  stays  on  the  line)
```

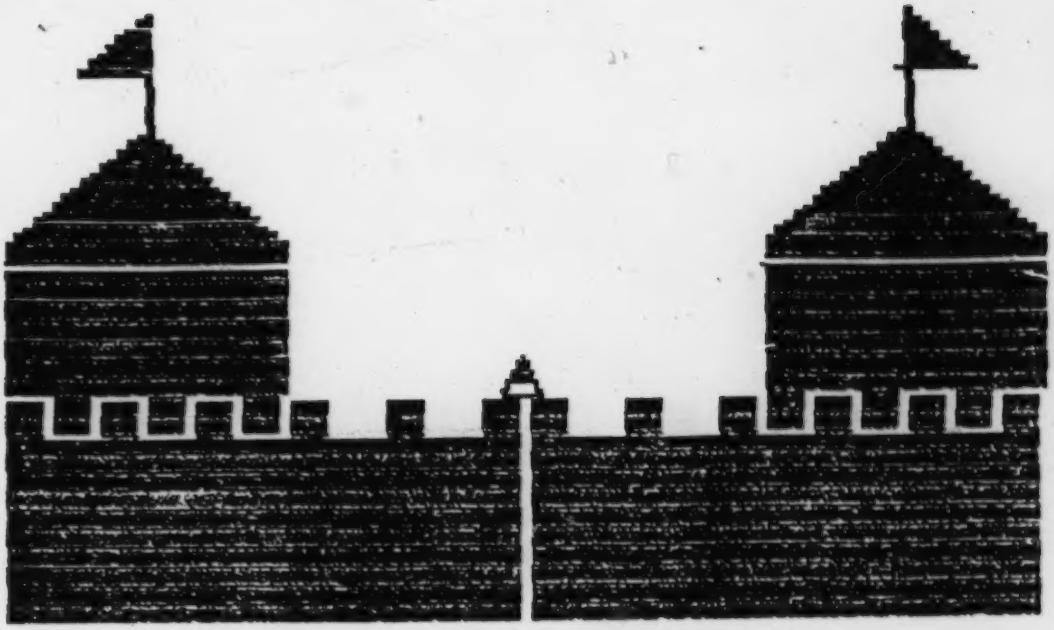
7. **castle**

Imagine that you could take your Logo turtle to the beach. Teach your turtle to build a castle.
You might want to plan your work first. An example of one plan is included to help you with your project.

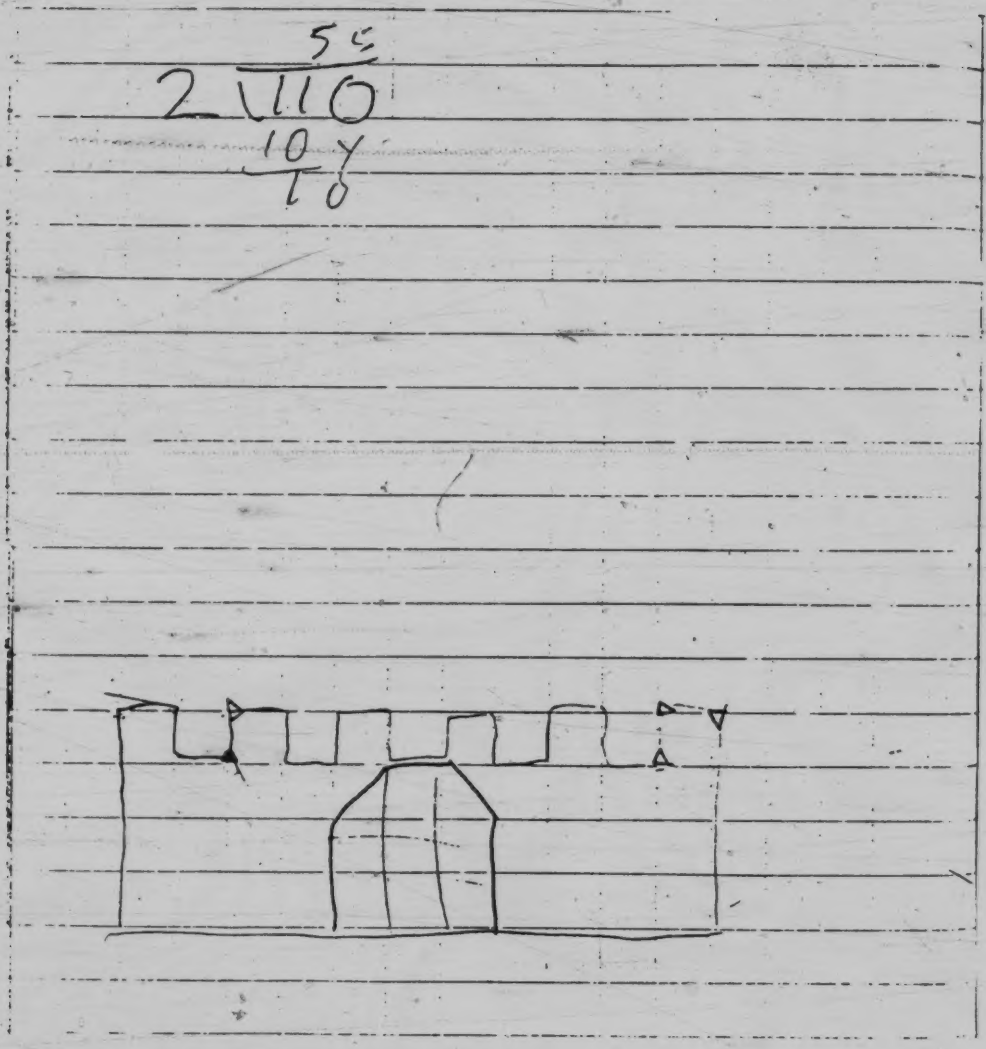
```
TO CASTLE.JOHN
WALL
SMALL.TOWERS
LARGE.TOWERS
MAIN.HALL
END
```



Jean and Karen's Castle



A Page from Jean's Book



Jean and Karen

March 15, 1989

```
to wall
fd 10 rt 90
fd 10 rt 90
fd 10 lt 90
fd 10 lt 90
fd 10 rt 90
fd 10 rt 90
fd 10 lt 90
fd 10 lt 90
fd 10 rt 90
fd 10 rt 90
fd 10 lt 90
fd 10 lt 90
fd 10 rt 90
fd 10 rt 90
fd 10 lt 90
fd 10 lt 90
fd 10 rt 90
fd 10 rt 90
fd 60 rt 90
fd 110 lt 90
end
```

WALL

J "Good but I have to move it"

```
CS
setset
wall    (makes 1 wall in bottom left)
```

K "Now are you going to make a tower?"

J "I have 2 here (walls) but first I want to change that. I want to go lt 90

K "so lt 90"

```
lt 90
ed "wall

to wall
fd 10 rt 90
fd 10 rt 90
fd 10 lt 90
fd 10 lt 90
```

```
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  60  rt  90
fd  110  lt  90   (added  lt 90)
lt  90
end

K  "You  need  another  one  (lt  90).  It  goes  down."

J  "I  want  it  to  go  that  way."

K  "Why?"

ed  "walls

to  walls     (talks  through  instructions)
setset
wall
bk  110
rt  90
wall
end

J  "Maybe  I  screwed  it  up"

cs
walls  (one  wall  as  before  with  another  in  split  screen)

J  "Yeah  I  screwed  it  up"

K  "Let's  see  what  you  did.  You  got  this  far....."

J  "I  know  what  I  did  so........"

ed  "walls

to  wall     (took  out  last  lt  90)
fd  10  rt  90
fd  10  rt 90
```

```
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  60  rt  90
fd  110  lt  90
end

K "Well?"    [[she doesn't understand why lt 90 was
removed]]

cs
walls    (get 1 wall as before and the other one in its
side)

J "Now what's the problem? I took out 1 lt 90 do you
think I should take out another?"

K "I'm not sure maybe it should be rt 90"

J "Well let's first take out this"

ed "wall

to wall     (took out last lt 90)
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
```

```
fd  10  lt  90
fd  10  lt  90
fd  10  rt  90
fd  10  rt  90
fd  60  rt  90
fd  110
end
```

walls (2 walls side by side)

J "Good. I was trying to remember what I did last time." [[checking the parts of the procedure]] "I had better save this."

K " I'm going to make a procedure for tiny gates. fd 40 ... maybe fd 20" (working in her book)

walls (2 walls side by side)

J "Let's make a tower"

K "How big do you want it?"

J "I'm going to make it the same as your's"

K "but mine is set right there (setdown)"

J "I know. I'm going to make a different setup. fd...."

K "You kept making 2-2-2"

J "I know that's what I want to figure out. So now I go.....I'm going to go bk....."

K "So that's 110.....rt 90.....fd....How much are your squares?"

J "Every square is 10"

K "so fd 70"

```
bk  110
rt  90
fd  90    (line is too long)
```

K "fd 70"

J "oh let's start over"

(talks through)

```
walls
bk  110
rt  90
fd  70    (line  is  too  long)

J  "the  walls  are  only  60.  Let's  start  over"

K  "Well  why didn't  you  tell  me"  "So  your  walls  are
right  here."

J  "Let's  make  the  walls  (tower)  right  here."

K  "so  you  have  to  go  60,  70,  80,  90,  100"

J  "100"

walls
bk  110
rt  90
fd  100   (made  line  for  the  tower)

J  "I'll  do  rt"

K  "To  make  it  behind  you  need  to  go  lt"

J  "But  I  don't  want  it  behind  I  want  rt"

rt  45
fd  20
fd  20

J  "I'll  take  40"   (too  far)

pe  bk  10

K  "But  you  won't  have enough  room  (for  the  other  side)"

J  "so  I  will  go  lt"

cs
pd  walls  bk  110      (talking  it  through)
rt  90  fd  100  lt  45
fd  40

K  "Why  are  you  putting  lt  45  fd  40  in?"

J  "Because  I  want  it  to  go  down  and  touch  the  wall"

K  "Well  you  shouldn't "

lt  90
```

```
fd  40
lt  45
fd  40
ht
st

to  tower
walls
bk  110 rt  90
fd  100
lt   45
fd  40
lt  90
fd  40
lt  45
fd  40
end

tower    (2  walls  with  the  tower)

K  "go  to  tower  and  change  all  the  lt  to  rt"

rt  90
pu
fd  120      (gets  to  the  other  edge)
fd  30
fd  20
fd  10
bk  30
fd  10     (gets  to  the  other  end  of  the  wall)

K  "Go  to  the  tower  procedure  and  turn  everything  to  rt"
"No  we   have  to  go  fd  40"

J  "Okay  tower2"  "fd  40"    (talk  it  through)

K  "We  don't  have  this  in  a  procedure  by  the  way."

fd  40
bk  40  pd
fd  40
rt  45
fd  40
rt  90
fd  40
rt  45
fd  40  ht  st

to  tower2

K  "How  did  you  get  over  there?
```

```
J "Both together would be 220 minus 80 (width of 2
towers) is 140"

pu
fd 140
pd
rt 90      (talked it through)
fd 40
rt 90
fd 40
rt 45
fd 40
end

J "This is going to work and it wil be so perfect!"

cs

J "I do tower tower2"

tower tower2  (2 walls 1 tower with second one in the
sky)

J "What happened. I put rt instead of lt"

fs
ed "tower2

to tower2
pu
fd 140
pd
lt 90    (changes rt to lt)
fd 40
rt 90
fd 40
rt 45
fd 40
end

tower tower2    (2 walls 1 tower with the second tower
at 90 degrees to the first)

ed

to tower2    (no changes)  (looked carefully)
cs
tower (2 walls 1 tower)

[[she did the part that works to see where the turtle
is]]
```

```
K "Let's see what's wrong"

rt 90

J "I didn't put it in yet"

R "You were just trying it first?"

J "Yes"

ed

to tower2  pu
rt 90 fd 140    (added rt 90)
pd
lt 90
fd 40
rt 90
fd 40
rt 45
fd 40
end

tower tower2    (2 walls 1 tower with the other tower at
the right end but upside down)

K "At least it's not going sideways"

J "I have to edit this I know what's wrong"

K "Sure that's what you said before!"

ed

to tower2
pu
rt 90 fd 140
pd
rt 90     (changed lt to rt)
fd 40
rt 90
fd 40
rt 45
fd 40
end

tower tower2    (second tower is only a few steps off)

J "There.....almost"
```

APPENDIX B

TRANSCRIPT OF A VIDEOTAPED SESSION

Appendix B is a sample of a transcripted computer session. Observational notes have been incorporated into the transcript. Observations are enclosed in single square brackets [ ], while the researcher's reflections are enclosed in double square brackets [[ ]] . In an attempt to show continuity, the sample was selected because it was followed by a conference which is transcribed in Appendix C.

A is Anna

S is Susan

R is Researcher

Feb 27, 1989

(This is a new project. They are making a design using variables)

[[Will they take the idea of making it fancy?]]

A "Okay write this down"

* [Susan writes down the instructions as Anna tries it. Anna checks the instructions with Susan]

?FD 20
?BK 10
?RT 45
?FD 5

```
A  "Fd  5  right  because  that's a smaller  one"

?BK 10
?FD 5
?LT 90

A  "90?  we're  going  this  way"

?FD 5
?BK 10
?FD 5
?RT 45
?LT 90
?FD 10
?BK 20
?HT
```

*[[once again they tried it out then wrote a procedure]]

[they talk their way through the instructions]

*[[This time they put the variable in right away]]

```
?TO CROSS
>FD 20 *:SI
>BK 10 * :SI
>RT 45 FD 5 *:SI
>BK 10 * :SI
>FD 5 * :SI
>LT 90 FD 5 * :SI
>BK 10 * :SI
>FD 5 * :SI
>RT 45  LT 90
>FD 10 * :SI
>BK 20 * :SI
>HT
>END

?cross  2        (nothing)

?ED CROSS

TO CROSS   :SI        (added  :si)
FD 20 *:SI
BK 10 * :SI
RT 45 FD 5 *:SI
BK 10 * :SI
FD 5 * :SI
LT 90 FD 5 * :SI
BK 10 * :SI
FD 5 * :SI
```

```
RT 45  LT 90
FD 10 * :SI
BK 20 * :SI
HT
END
```

?CROSS 2 (makes a cross with a smaller cross at 45 degrees to the first one)

```
?ST
?FD 20
?RT 90
?FD 20
```

A "Now what would that be? - 135?"

S "Yeah - well let's just try it"

```
?RT 135
```

* A "Well how much would that be? Well pu (try it with no lines)"

```
?PU
?FD 15
?BK 15
```

A "How much maybe 12"

S "Well let's figure it out - 1.41 times. We did something with the size of the line and this number. Remember if you have this side and this one you can figure out the other one. We only want this one."

R "How long are these lines?"

* [Anna uses her fingers to measure the amount of space]

R "It only works on lines that are the same length"

```
?FD 13
```

A "Okay how does that look?"

* [She used the guess - check - adjust method to try to find the length of the side]

```
?BK 13
?PD
?FD 13
?HT
```

```
A "It's going to go right past it"

R "so it has to go down more"

A "So what is it?"

S "I'd say rt 2"

?ST
?PE BK 13
?LT 135

R "Well I think you have to turn it more not move it"

A  "Okay 137 - 138???"

?BK 2
?RT 138
?FD 13
?BK 13      (forgot pd)

?PD
?FD 13      (it touches)

S "Good guess"

?HT
?FD 13  (goes past the line)

A "No it's not the same"

?PE BK 13

S "If this is 10 (line) then this line must be 10 but
at a different angle"

A "It's how much?"

?LT 3
?FD 13
?BK 13
?PD       (forgot pd)

?FD 13
?PE BK 13
?PD
?LT 3
?FD 13
?PE BK 13
R "Well that's better"
```

```
?PD

S "I'd say off 1"

?LT 1

A "That's 9. Why not make it 10"

?LT 1
?FD 13     (not bad)

?ST
?RT 90
?LT 90
?RT 138   [[to make it the same as before]]

?LT 138

?SETH 90    (in order to get it facing straight)

R "Now it's facing straight out so try 138"

?RT 138
?FD 12
?HT               (it worked)

?ST
?RT 10
?LT 20
?FD 13
?HT            (have one half of the star design)

?ST

A "seth90"

S "180"

A "no no 90"

?SETH 90

A "oh it's that way"

S "Well just go rt 180"

?RT 180

A "Write this down"

?LT 90
```

```
?RT 138
?FD 13

?RT 10

A "NO IT'S LT 10"

?LT 20    (to compensate)

?FD 13
?HT       (A "see!")

?ST
?SETH 90
?LT 180       (heading straight out)

?RT 138
?ED 13
?LT 10
?FD 13
?LT 45
?RT 15          (completed the design)

A "No you don't have to write this down"

?H

R How did you get the direction down here (at the
bottom)?"

A "I don't know. um....we used seth and then moved lt
180"

R "So it was going a different direction?"

A "Yeah"

R "So this is 0 and this is 90.......Yes I just
noticed that as well(that they had turns that would
cancel out others).......just try it in a procedure"

?HT
?CS

A "Did you write down how to get to here (points)"

S "Yes"

?TO FCROSS
>CROSS
>FD 20 * :SI
```

```
>RT 90 FD 20 * :SI
>RT 138 FD 13 * :SI
>LT 10 FD 13 * :SI
>SETH 90 RT 138
>FD 13 * :SI
>LT 10 FD 13 *:SI
>STH 90 RT 180
>LT 90 RT 138
>FD 13 * :SI
>LT 10 FD 13 * :SI
>RT 90
>SETH 90 LT 180
>RT 138 FD 13 * :SI
>LT 10 FD 13 * :SI
>HT
>END

fcross

NOT  ENOUGH  INPUTS  TO  CROSS  IN  FCROSS

?ED FCROSS

TO FCROSS  :SI
CROSS
FD 20 * :SI
RT 90 FD 20 * :SI
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
SETH 90 RT 138
FD 13 * :SI
LT 10 FD 13 *:SI
STH 90 RT 180
LT 90 RT 138
FD 13 * :SI
LT 10 FD 13 * :SI
RT 90
SETH 90 LT 18
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
HT
END

S  "DON'T  you  need  it  in  cross"

A  "I  did  it  in  cross"

S  "but  just  put  * :si"

A  "like  that"
```

```
?ST
?FCROSS
?FCOSS 2
?ED

TO FCROSS  :SI
CROSS * :SI
FD 20 * :SI
RT 90 FD 20 * :SI
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
SETH 90 RT 138
FD 13 * :SI
LT 10 FD 13 *:SI
SETH 90 RT 180
LT 90 RT 138
FD 13 * :SI
LT 10 FD 13 * :SI
RT 90
SETH 90 LT 18
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
HT
END

?SS
R "When it's beside a name like that I think you don't
need the *"

?ED FCROSS

TO FCROSS  :SI
CROSS  :SI
FD 20 * :SI
RT 90 FD 20 * :SI
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
SETH 90 RT 138
FD 13 * :SI
LT 10 FD 13 *:SI
STH 90 RT 180
LT 90 RT 138
FD 13 * :SI
LT 10 FD 13 * :SI
RT 90
SETH 90 LT 18
RT 138 FD 13 * :SI
LT 10 FD 13 * :SI
HT
END
```

?FCROSS 2 (starts out right but after first turn after seth 90 it moves over farther)

A & S "oh no!"

R "This part worked"

A "It looks right up to here (points)"

R "You were right that we didn't need the multiplying sign at cross"

A "This part where we have 13 - it would be one half of 13 because in this part we did 2 and 2"

S "Why not use 13?"

A "Well when we put CROSS 2 its going to double 13 so we need to put one half of 13 ..... get it?"

S "Yeah I think so"

?CS
?SAVE STUFF3

R "Did you figure it out?"

S "no"

R "Well you'll have a place to go next time then"

APPENDIX C

TRANSCRIPT OF A CONFERENCE

Appendix C is a sample of a transcripted conference session. This conference took place after the computer session in Appendix B.

ANNA / SUSAN FEBRUARY 27

(talking about variable in the title)

R And then we put 2 coincides with the S. That's like putting down across 3 or whatever, so it would just take the number you put in from the top through the whole procedure into that place it would make it -- like if you put 2 for a supercross, supercross 2, then where it said cross in there it would just put the 2 beside it, so it should come out twice as big. But we didn't have to put the times in there as well because that isn't the way that you would write. That's what we were what we were having trouble with. So, I don't know, I don't think that's it, I think it might have had something to do with the direction you were going. Or the direction you started from. We'll have to check that.

S The cross was okay but I think it's just what the other part.

R The cross was trying to get the lines around it. That was the problem.

S Right.

R One thing that I saw that you were doing here again was trying out everything first and then when you got it in then you decided to put it into procedure. You want to be really safe when you do that. Not take any chances.

S Yeah, cause then you know when you went wrong and stuff so.

A But this time I don't think we knew when we went wrong on the very last part.

R I think you tried it a little too fast.

(Susan mumbles things about going too fast.)

A Yeah.

R I wonder what this does - double speed. It's a little bit fast but then we can still see what's happening here. That worked out pretty well. The cross seems to be fine.

S Anna, I think I know what we did wrong. When I wrote it down, I said at the end it was turning a certain way and you said you don't have to put that down, so I didn't, and it was at an angle.

A Now I changed it back.

S I never put it down.

R Now that's what we could do.

A It ended up facing this way and I was trying to go like that but I couldn't get it. I don't know, I was just fooling around, I thought just leave it so I just left it going like that too.

R Maybe that's something we could check, if you think that maybe it was going in the wrong direction, it was going in the wrong direction because you had left out that one part.

S I forgot where it is.

S It says forward 20, the cross ends up right here -- I don't know where it ends up -- something like right here.

A No, it goes like this, there, and then we did this one, then we did that one, then we did that one, I think and then I don't know where we end up.

R Yes, so I guess that's important though. Where does it end up?

S Oh, I remember, we ended up right there, at our cross, then we went over here, up here, then we did this part.

R To get back.

S That was right, then we did this and this and that.

A This is forward 20, it goes there, back 10, right 45, so we're doing this one, back 10, and then forward 45, left 90, so it's going this way now, 45 back 10, 45 right 45, so we're going this way now. Forward 10, back 20, hide turtle, end. So we ended facing right there.

S Then we went over 20 right 90.

R And that's what happened remember, you went way out here, so that's what's wrong.

S&A Forward 20, left 90,forward 20 that's right. I think the rest is right.

R Okay, that could be, so you got it all worked out now, because you thought it was up here and it worked.

S&A We thought it was right here, facing that way, see forward 20, right 90, forward 20.

R But you find out that it's actually facing that so you have to get it back and up and then turn. Okay.

S The rest of it worked out it's just that they were separated over here.

R So here's where we first experimenting with and I noticed again you were using this idea of which direction to go, but you didn't know exactly, so you checked and then you adjusted again.

Okay. We should almost be at the part so we can tell.

A That's strange that it would be 138 instead of 135.

(They keep working on ideas in their books while the video is playing. They glance at it but are working on new ideas.)

R But it definitely seems to work at that.

Okay, this is the part that I wanted to stop it for a minute, when you decided on how far to turn it here, you see it took you awhile to try to decide how much to turn it? Okay, so you've tried setting the heading to 90 again, which put it at the side, now I just want to show you something I think that it would find it easier if we just learned .....

A Set that at 180

R Yeah

S That's what I kept saying.

R Okay, it's 090, 180 and 270 this way. Sometime from this way it's just pointing a direction, it's going all the way around the number of degrees around. So you're right, it could be 180 there instead of, I think if you worked it out what you get when you add all these together probably turns out to be 80 because you did it

at 90 then you turned it to the right 180, so you turned it all the way around there, and then you turned it left 90 again, the 90 and 90 cancelled each other out so you're left with 180. Maybe when you get the next one it will come out to 270.

S That's 90 so, oh my God.

R I see you worked it around so it was left 90 that's okay, but it's still. If you were going all one direction it would be 270 or 90 the other way. I don't know how to H (remark from the computer).

A Maybe another way we could have done this is just doing half of it, cut it in half and just do half of it, and repeat it again.

S Just have the turtle facing a different way.

R You could do that, like if you did the top half.

S It could be on the right part.

R And then you could get the turtle facing the other way and it would make it down, or if you did this side you'd have the turtle facing the other way and it would make it on the other side. Or as you said as well, I suppose that another way of looking at it, you could change all the rights to lefts then it would just go the opposite direction. So you think you have it figured out now?

A&S Yeah, it should work. I hope so.

S And it doesn't.

R This is the one where we had to take out the NOT ENOUGH IMPUTS to cross in F cross. This was the first time we had not put it in beside it.

A Is this the part where you change this to set heading 180?

R Pause.

S Write what was in there.

R Okay, so it went straight forward then it turned 90 and went up and then it did the instructions that you had given it.

S I don't know where it started.

R Well, it must have started right in the middle. Forward 20, back 10, right 25. Oh, I see, it started right down here. You went forward 20 back 10, then you went up this way to make the cross, so it made the cross then it got out to there and you said forward

20, so it said "Okay I'm going to go" and it went right over there. But now you have to see - Have you fixed that by doing this?

S I doubt it.

R Cross then you put forward 20, is that going to end up in the same place?

S No.

R It's going to end up in the same place as this. Right? So let's see, so we've got something that looks like this.

S But I am wondering why it is so big?

R Yes, I am wondering about that too, but how about we work on one thing at a time. Actually this looks twice as big as that. We'll have to work on that.

S Cause this one still looks like a small one. It looks like a 2 but this ones 4.

R It looks like it wouldn't meet up. We will have to work on that one. Right now, whe you get finished your cross, the turtle is facing that way, so then you told it to go forward and it did. So do you want the turtle to really be here or do you want it to be here?

A&S Right there, facing there.

S So to start, you would have to be back 20.

R So at the very beginning you could say back 20.

S Back 20, left 90 and then that's right. Instead of forward, it's back, that is the only thing that is wrong.

R Actually, that's true, when you get left. The question is, is it left 90?

S No, it's right 90. I'm looking at a different angle so ...

R Forward 20, right 180, forward 13,

S The rest will work.

R Left 10, forward 13, set heading to 90, right? Yes, the rest looks alright. And then what I was saying before about the set heading 90 and then with all these rights and lefts in here, you really could have set heading 180. And save yourself some there. I see what you did, you set heading 190 so it went this way and then

you said "Okay, I'm going to go left 180" which takes it around that way. Intead of doing that you can still put set heading 270, add them together. But that still doesn't solve this problem of it being too big, I wonder what could have done that? When you ended up with all signs and variables to cross so this should be forward 20 times the size, this should be back 10 times the size. You're right. It does look too big.

S This part's fine, the barrier. Actually it might work. I don't know we just have to try it because we're looking at it differently.

R It's hard to look at it, you're right, I think at a different angle.

A We should put the whatever to 13 instead of 6.5 and then it will just double it so it will make 13. and that will be the same size as the cross.

R Although you figured it out on the cross that was this size, right? Or did you already multiply this cross when you put it in and then you tried 2. I just thought of something.

S That is the double sided cross. But the same cross is this big or something.

R I think that's it. What you did when you started you made the procedure and then you crossed the 2 and that's what we worked out this one on. So that when you doubled this one again you could see the figure. You're right, so if that's cross 2 then you're right, these should all be in half.

A It's forward this and it's forward the 6.5.

S There's about a million of them in here.

R But it looks like all of these should be like that back 20, forward 20. I think all the numbers for distance should be in half and then it would be in the same proportion as the cross that you made. Well that was good thinking Anna, that you'd already changed it once. So you'll end up with some strange numbers.

S Okay, now it should work.

R Well, that feels good to have solved the idea. I couldn't think about what was going to be wrong.

A So everything else will be the same.

R So all the angles and everything are going to be the same. It was just the length of the line. Well good. So that should solve

that problem and you can do that right away the next time. So what were you going to do with it after this? Did you have any ideas?

S We could make that a pattern.

A Yes like a whole bunch of them together.

s It would have a little diamond shape in there. This one go there and this one go there and this would go over there.

R Yes, you could make it just like you were doing there, make it attached by the point. I suppose you would have to figure how far this was, to figure out how far to move it over.

S That's not so hard because it's even.

R It is pretty even. Those lines at least are even, even if those ones aren't. So you can make rows like that. Could you do anything else?

S You could make a circle.

R Yes, if you attached 130, attach 190 and up.

A We could do something like a throwing star.

R When you said a circle, I thought you meant you could have one and you could attach one down in here, all the way around so it would look more like a circle.

S Now it's not a Nazi sign.

R Could you do anything else?

R Yes, I think if you overlapped it it would look really neat, If you started overlapping it different ways. You might overlap just...

S Like 2 or 4

R ...little tiny bits, or you might rotate it around this point.

A Different colors.

S Right 2 repeat 20 times.

R Right you could say repeat 20 and put both the turn and the full cross together, that would probably turn out to be an interesting design. But like you said too, to try to overlap them or even in different sizes so it might even have that 3

dimensional look. Like they were trying before with the numbers. to cross 1, to cross 2, 3,4,. See what would happen there. So you could have lots of different ways of doing that. But I guess the first problem is to make use of the procedure worked out right, but I think that you have resolved that one. That was good thinking, that could have taken us a long time looking at other ways to come across that. It's lucky it popped into your head. To do that, so we can do that and then you could work on different ways of doing it.

APPENDIX D

RESEARCHER'S COMMENTS

Appendix D contains graphwork depicting the type and frequency of the researcher's comments.

The researcher's comments during computer times and conferences were classified as to intent. The classificatons were:

1. **probe**: Questions were asked or statements made in order to have the participants intensify their exploration of an idea.

2. **tell**: Information was given.

3. **explain**: The researcher explained the reasoning behind concepts.

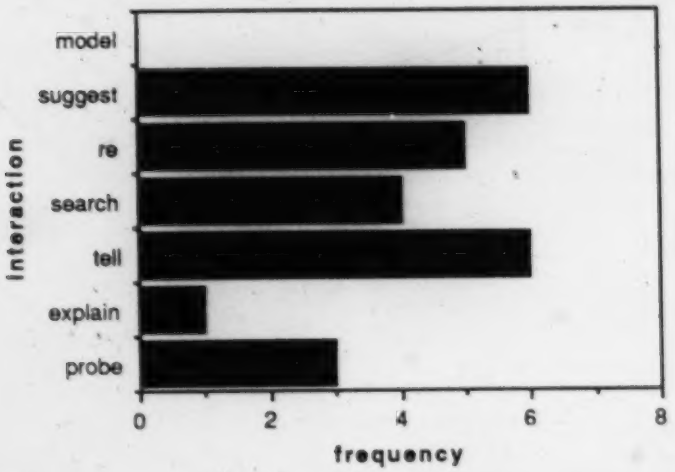
4. **suggest**: The researcher made suggestions for future action.

5. **re**: Statements were made which reinforced the student's action or thought.

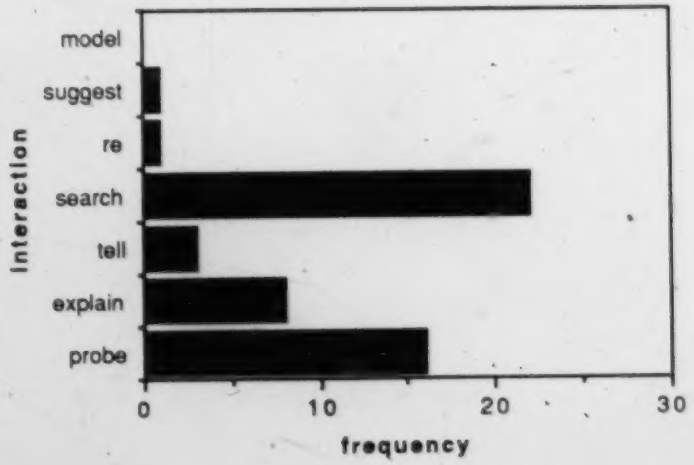
6. **search**: During a search, the researcher's comments were directed towards uncovering the problem area.

7. **model**: The researcher was attempting to demonstrate a method of reflection which the participants might use in a similar situation.

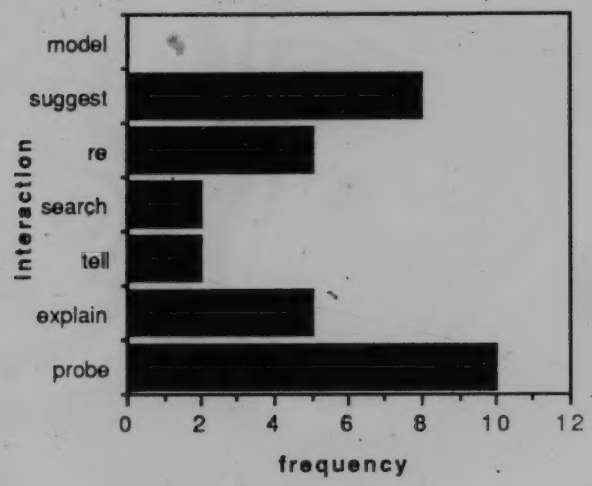
Data from "Researcher - Jean and Karen"



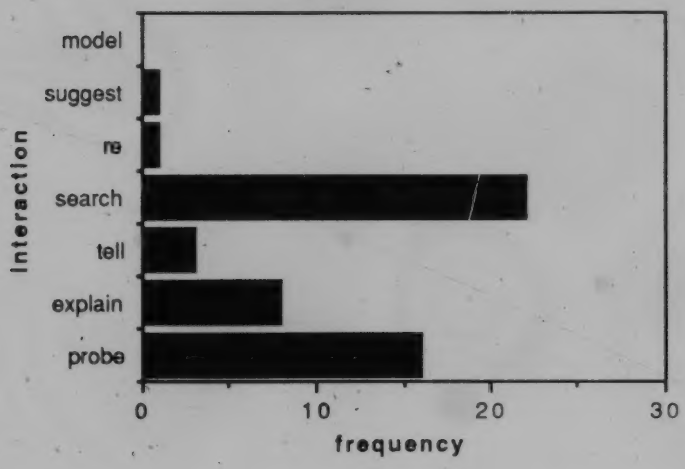
Data from "Researcher - Ross and Simon"



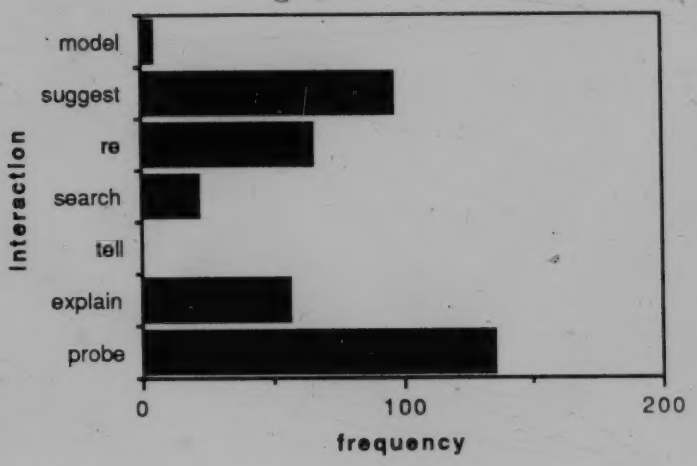
Data from "Researcher - Anna and Susan"



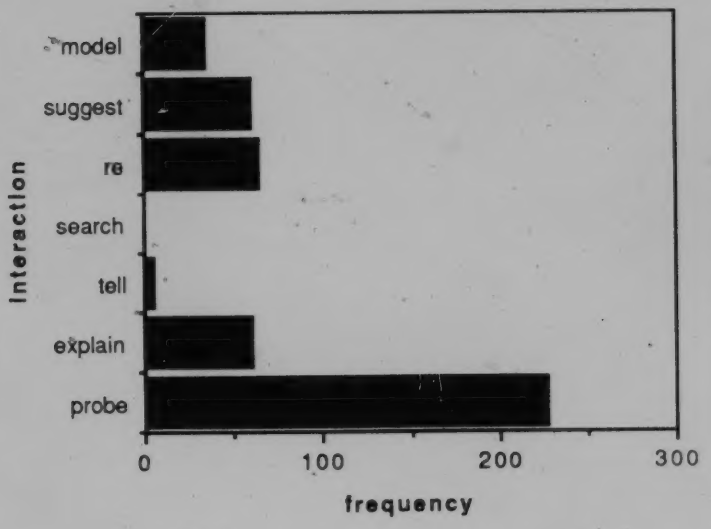
Data from "Researcher - Alan and Mike"



Data from "Researcher - conference - Anna"



Data from "Researcher - conference - Alan "



APPENDIX B

SIGNS OF FRUSTRATION

This Appendix lists the number of "signs of frustration" exhibited by each group and each individual during computer sessions. These signs of frustrations were comments which indicated frustration or an action such as banging the keyboard.

Whether or not the group was conferenced is indicated.

Signs of frustration

		group total	
Anna	4		conferenced
Susan	2	6	
Alan	19		conferenced
Mike	3	22	
Ross	15		not conferenced
Simon	12	27	
Jean	13		not conferenced
Karen	38	51	

APPENDIX F

CONSOLIDATION OF INFORMATION FROM INDIVIDUAL INTERVIEWS

Name

Date

General Information

1. When you are working with Logo do you like working alone?

6 no

1 sometimes

1 no but for me it might be better because I'd get more done

2. What do you like (not like) about working alone?

<u>like</u>

- you don't have to explain things
- you don't have to get them to agree to everything
- I do do more because I don't talk so much
- I have my own ideas
- There is no one else to blame

<u>don't like</u>

- it's boring
- you get ideas from the other person
- It's hard - someone has to write things

3. Do you like working with someone else?

7 yes

1 sometimes

4. What do you like (not like) about working with a partner?

<u>like</u>

- the other person can pick out mistakes
- you can get their opinion
- there is someone to discuss the problem with
- you can talk and get ideas
- they help to figure things out
- it's faster
- you can get help

<u>don't like</u>

- can't always work on your ideas
- don't always have enough time to finish
- sometimes the other person doesn't always help with the solution

5. How did you feel about working with _____?

7 good - they're my friend

1 sometimes I felt upset or grumpy

6. Did you have any problems working with _____?

- argued over ideas
- sometimes it wasn't much help because they aren't thinking of the same things

-sometimes they didn't explain what they were doing

- sometimes they don't pay attention to the problem
- they don't always type what you want
- sometimes we get on each other's nerves
- we have different ideas
- they were fooling around

7. Do you learn more working by yourself or with someone else?

7 someone else

1 by myself

8. Why?

- get more ideas
- both people learn stuff
- "I like to ask someone what they think"
- they remember other things
- * by myself because I don't pay as much attention when there is another person
- * when I'm by myself I have to do things by myself

9. I noticed that _____ is the way you work. How did that happen?

6 just happened

2 decided

10. What things do you do to decide on your next step in a problem?

1. type different things
2. look at the posters with instructions

3. fool around and try to get close (guess - check - adjust)

4. work from the picture in your head

5. look back at the list of procedures to see if there is anything you could use

6. move the book around to calculate the angles and direction

7. go to the editor

8. do 1 step at a time

9. use finger [to show direction or to measure]

10. use hand to figure out the angle direction

11. talk it out

12. plan the easiest or main thing

13. use grid paper

14. draw in your book

15. think

11. Is there anything which helps you when you're stuck and not sure of what to do next?

- talk - "2 minds are better than 1"
  - "other people look at it differently"
  - sometimes they can see the mistake when you can't
- try and keep trying
- try it with the pen up
- guess - check - adjust ("you can tell if it needs to be more or less")
- ask someone who has done it
- ask the teacher

- write down ideas
- do something else and come back

12 What do you do when you can't figure out what to do to make your idea work?

- look around
- ask other people
- stop and do something else 2. (until I can think of an answer)
- talk
- keep trying
- draw a picture
- use the squares on the grid paper to figure out some things
- ask a friend - sometimes they look at it in a different way - you can't see it but they can

13. Is there anything that might help you if you're stuck or frustrated?

- ask the teacher
- try doing something different - when you come back you know what your problem is because you see it right away
- think it out
- fiddle and diddle with things and see what to do
- forget about it and do something new

14. Can you remember a time when talking to someone else helped you solve the problem or decide what to do next?

7 yes with examples

1 no

15. Which Logo project did you like best?

5 castle

2 letters

1 checkerboard

16. Why?

It was challenging.

You can be creative. You can make what you like.

You can pick your own project. You can do lots of things with them.

It was the most interesting.

You add your own stuff.

You use your own ideas.

17. Which Logo project did you like the least?

4 dividing rectangles - boring

2 initials - angles too hard

1 tessellation - too hard to find a shape

1 putting polygons together (tessellation) - too easy

18. Why?

19. Do you like projects in which the teacher tells you exactly what to do?

7 no - I like to do what I want
- I like to be creative

1 yes - it makes it easier

20. Why do you like the projects that are a challenge?

- You have have to think hard.
- You have to think. You can't do it in one day.
- You have to break it down to the easiest way.
- You have to decide how to solve it.
- You feel little when the teacher tells you what to do. When it's a challenge you feel more responsible.

_They're sort of hard. You have to figure it out.

- You learn for yourself.
- You get to use your own ideas.
- You can be creative.

conference groups only

21. How did you feel about talking to me about your project?

- liked it because I could explain the problems and figure out ways to solve them
- "anything to miss school especially spelling"
- It helps. We can figure it out together.

22. Did coming and talking help you with your projects?

- yes - you helped us fix it
- sometimes - if we saw where we went wrong we could go to that spot
- yes - it made me understand more
- yes - we learned how to solve some of the problems

23. Can you think of a time when our talks helped you?

- at first I got more things on my disk
- when we talked about the rectangle you saw a completely different way

- angles in the letters

- the pentagon - we couldn't do it

- robot

24. Do you learn more when you talk to other people about your ideas?

-yes

- talking helps - you learn more from discussing

- "learning to solve problems by yourself is tough"

- sometimes - can't just do or tell - must show (or guide) because "when we are figuring out things ourselves then we remember more"

25. Do you think you would learn more in the situation where the teacher can sit down and talk to you once a week or where the teacher comes to make comments as you are working.

- once a week because we could have long discussions about the problems I was having

- once a week - you learn more from discussing

- it depends if we need any help at all - sometimes all you need are comments [[these two didn't often need help and liked their independence]]